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SCIENCE AND INDUSTRY

VOLUME V

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ERRATA

Page 626, second column, line 18, should read "in the tank, and as long."

Page 627, second column, line 31, should read "especially where condensed exhaust steam is to be."

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SCIENCE AND INDUSTRY

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THE ART OF WORKING IRON

Maurice M. Sloan

THE EQUIPMENT OF THE SHOP—INTERESTING METHODS EMPLOYED IN THE MANUFACTURE OF ORNAMENTAL WROUGHT-IRON WORK

SINCE the time of Solomon the ironworker has been recognized as an artisan of rare attainments. Vulcan was worshiped by the Romans as the god of fire and the worker of metals. He was the divine artist, the creator of all that was beautiful as well as all that was mechanically wonderful in the abodes of the gods, and, like the smith of today, he depended on the forge and the hammer as the principal implements in the practice of his craft.

Our modern ironworker possesses few tools compared with the artisans practicing the contemporaneous industrial arts, but he is ingenious, and makes the best use of those at hand, greatly widening their sphere of usefulness by the adoption of simple devices peculiar to the shop wherein they are employed.

However, as we are acquainted with the proprietor of an industrious shop turning out the usual run of ornamental ironwork now

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required by the architect, let us obtain his permission to go through the works, and see whether our observations will not give us a better understanding of the manufacture of wrought work, as applied in architectural and decorative art.

As we step inside the door, a cursory glance around the shop reveals several jobs under way, which vary greatly in character, and are more or less in progress toward completion. The equipment of the shop is fair, and by the ingenuity displayed in the operation of a few machine tools, is very efficient.

The smith shop contains several open forges, the air blast being generated by a centrifugal belt-driven fan. The smoke and gases from the forges are carried through the roof by cylindrical flues, the lower ends of which are about 3 feet above the fire. Several light power hammers of the trip or tilting variety, the usual anvils, hand hammers, sledges, fullers, and tongs complete the tools in this section of the shop.

Let us watch, for a few moments, the workman over in one corner of the smithy. It is evident that he is laying out some new work, and judging from the drawing it is a massive iron fence of good proportion and design. How interesting it is to watch him as he transfers the architect's full-size brown-paper detail to the sheet-iron plate. We asked him why he did this, and he told us that the smith, in order to work his iron to the form shown on the drawing, must repeatedly lay the hot forging on the outline of the design. This would destroy the paper drawing on the first trial, and, consequently, the design must be reproduced on a sheet-iron plate, where it remains intact until the work is finished. Notice how readily the transferring is accomplished; the workman rubs the back of the drawing with chalk and lays the paper, with the chalk side down, upon the plate, going over the outline of the design with a lead or soapstone pencil, thus transferring the chalk to the plate along the lines passed over by the pencil. It is simply the operation employed by every schoolboy in the land, only the chalk on the back of the drawing acts as the carbon paper.

Just across the shop a sturdy smith and his helper are at work forming the frame of the fence standard, as laid out on the metal plate. A glance at the partially

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finished work around the anvil reveals the manner in which they proceed. Bar iron of the right thickness and width was selected, and cut to a length suited to make one half of the standard. The end on which the volute is formed was drawn out somewhat, and the volute turned; the required shear or curve is given to the vertical portion of the bar, and the other end turned to form half the base, allowance being made for a lap weld. The two halves of the standard are joined by welding, and the required curve to fit the top of the coping given to the base. With a few final blows the kinks are taken out, and the standard is ready for drilling and punching.

Before we leave the smith shop let us watch the trip or tilting hammer at work. The operator is using it to finish the top of a number of iron pickets for a fence. The top is ornamental in character, being a conical spear head surmounted with a ball and further embellished by a half-round bead an inch or two beneath the spear head. The picket heads have been rapidly roughed out by hand hammering and welding, and the dies in the tilt hammer, being of the required form, finish the head quickly and smoothly, provided good judgment has been used in welding enough material on the picket to neatly form the head.

From the smith shop we enter the assembling room. There is a large clear space in the center; on one side are the machine tools, on the other are the fitting-up benches. The machine tools are not heavy, for the work is light, and must be rapidly done. They consist of a power-driven alligator shear, two medium-sized drill presses of the usual type, a small screw-cutting lathe, an emery wheel, together with a set of 6-foot light sheet-iron bending rolls and a light vertical power punch. The foreman tells us that the shear is employed in cutting bar iron to length and plates to shape, but that it does not make a smooth job in cutting plates, and shows us how he has rigged up a set of shear knives that can be operated in the punch and which manages light work much better than the alligator shear.

It is evident that the man running the drill press must use his ingenuity to good account; for the shop is not provided with a slotter or shaper, and the drill press must be used in roughing out halved corners and notched joints. Let us examine the drill he uses for this purpose; it is ground square across the cutting edges, being set at 15 degrees, and is provided with an arbor formed at its center of revolution. This arbor, which acts as a guide, fits into a ¼-inch hole previously drilled in the bar that it is desired to halve or notch. When the drill, which is larger in diameter than the bar, revolves, it cuts the iron entirely away for half its depth, and no more, as the arbor is just that length, and prevents the drill from cutting farther. The cutting surface it made is flat, though it leaves a concave shoulder that must afterwards be squared with a file.

Our man to the right of the punch is keeping the emery wheel employed in smoothing off the rough places left by the blacksmith in bending or welding the spirals or ornamental shapes, and he often finds the emery wheel more rapid and efficient than the file in cutting away superfluous metal and forming dowels on pieces that are to be secured in the fabric of the design.

The lathe and the bending rolls have their respective uses: the lathe in drilling rivet holes in work that will not permit of punching or operating on the drill press, and in turning gate trunnions and general constructive and repair work about the shop; the bending rolls come in handy in breaking sheet iron to a required curve or in bending heavy flat bar iron to the arc of a circle.

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But time is pressing, and it looks as if the man operating the hand forge over at the other side of the shop were engaged in interesting work. What is that by the side of the forge? It looks like small pieces of brass, and he confirms the observation. Several wrought scrolls growing from one stem are to be united by brazing, and the use of the brass is explained. The bars of iron forming the scrolls are tapered at the end where they merge into the stem, and the scrolls are held in their respective positions by a piece of twisted wire. Notice how he places a brass chip, with some calcined borax, on the junction of the scrolls and stem, and lays the work carefully on the fire, propping a piece of charred wood over it so that the heat will be deflected downward upon the brass. It is necessary to thus deflect the heat downward; for we see that the iron is hot already, and the fine end of one of the scrolls seems about to melt; if the heat were not deflected downward on the brass, the iron would burn before the brazing could be completed. The brazier must turn the blower carefully, for even yet the brass remains solid, and the scintillations at the finer portions of the work clearly show that the iron is on the point of destruction. He, however, knows his business, for see, with a light tap of the poker the brass runs over the joint and through the interstices, which hardens when the work is removed from the fire, and thus securely brazes the pieces together.

The gallery railing in the center of the shop where large work is assembled offers an interesting study in ironwork of this character. The top rail is a light channel iron, and the intention is to secure to this a hollow cast-iron rail of tasty design. The scroll and wrought work are pleasing, and are put together in the several ways adapted to this work.

A close examination of the gallery shows that the several parts are secured with rivets, machine screws, welding and brazing, binding with bands, and notching and riveting over the tenons. The heads of the screws are often cut off and the screw flat-riveted; this makes a clean job where the screw heads are not intended to form a part of the design.

At the door through which we were leaving the shop our attention was directed to a couple of workmen engaged in the manufacture of the common diamond-mesh wire-screen guards usually seen over window openings and around elevator enclosures.

The wire is selected of such a diameter as is suited to the weight of screen desired, and is crimped so that the screen will have lateral stiffness, and so that the interlacing will be secure.

The foreman of the shop had rigged up an ingenious machine for crimping the wire. Let us see what it consists of. There is a frame similar to the headstock of a lathe. This frame supports in bearings two parallel shafts, to one of which the power is applied by a crank secured to a heavy flywheel, the other shaft being driven from this one by spur gearing.

The outside ends of these shafts—the ends farthest from that at which the power is applied—project beyond the frame and are squared and so arranged that crimping wheels with differently pitched teeth can be taken on and off, as desired. These wheels consist of a cast-iron blank form into the perimeter of which is mortised steel teeth or pinions, made of bar steel about 1 inch wide by $\frac{5}{16}$ inch thick.

These teeth do not mesh, though, in turning, the points of the teeth on the one wheel come central with the spaces on the other and enter them sufficiently to cause the wire passing between them to be indented or crimped, the length and depth of the crimp depending on the pitch and length of the teeth.

The wire is drawn from the reel through the machine, and is guided by one of the

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workmen and the guards provided at the sides of the crimping wheels.

Over on the large flat table adjacent to the crimping machine the wires are laid interlacing, after being cut to length, and are surrounded with a light channel frame, in the web of which holes are drilled, and through which the ends of the wires are passed and clinched, the ends laying snugly in the groove of the channel.

THE FIRST COST OF MECHANICAL DRAFT

Walter B. Snow

COMPARISON OF COST OF BOILER PLANTS WITH CHIMNEY DRAFT AND MECHANICAL DRAFT. THE INFLUENCE OF AN ECONOMIZER ON THE FIRST COST

WHEN any contemplated increase in efficiency is under consideration, the first question to be asked is whether the saving will show a fair return on the investment; for it is generally assumed that to secure increased efficiency, additional expenditure is necessary in the equipment, whether it be of a boiler plant, a cotton mill, or a machine shop. But in the consideration of the influence of mechanical draft on the first cost of a boiler plant, the interesting case is presented of increased efficiency secured at decreased cost of original equipment.

From the purely economical standpoint, mechanical draft offers the opportunity for greatly reducing the waste incident to the discharge of the hot gases, which is absolutely necessary with a chimney. This waste, when a fan blower was employed to produce draft, has actually been reduced to only 5 per cent. of the total heat of the fuel, while only 1 per cent. was necessary for operating the blower. It further makes possible, owing to the intensity of draft, the burning of the cheapest fuel, which is almost without exception very finely divided, and tends to pack closely. There are also economies incident to more perfect combustion, to smaller requirement for air supply, and to almost instantaneous response to a sudden call for more steam, which tend to increase the saving that may be shown in the operation of mechanical draft as contrasted with chimney draft.

These economies do not relate, however, to the first cost, except in so far as the fixed charges may affect them. A consideration of the first cost of the plant in which these economies are possible will, if we take a concrete case, serve to show what these changes will be, and will render evident the expense necessary for equipment with the fan and with the chimney.

In Fig. 1 is presented the plan of a boiler plant consisting of twelve modern water-tube boilers. These are set in pairs, and are arranged so that under ordinary conditions the gases pass through economizers placed

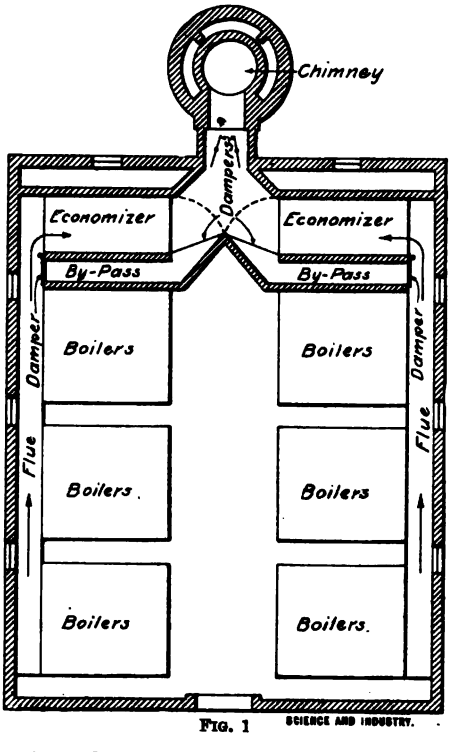

FIG. 1 SCIENCE AND INDUSTRY.

at the end of the boiler house. Each boiler is rated at 200 horsepower, the total, therefore, being 2,400 horsepower. A chimney 9 feet in internal diameter and 180 feet high serves to produce draft for the plant when the economizers are in operation. By-passes around the latter make possible the passage

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of the gases directly to the chimney when necessary.

Stated in round numbers, the cost of this plant, as given in detail and including the boiler house, is as follows:

12 boilers	$37,000
2 economizers	10,500
Boiler and economizer settings and by-passes	9,000
Automatic damper regulator and dampers	400
Chimney, including foundations	10,200
Boiler house	11,500
Total	$78,600

In Fig. 2 is shown the same plant with a mechanical-draft apparatus substituted for

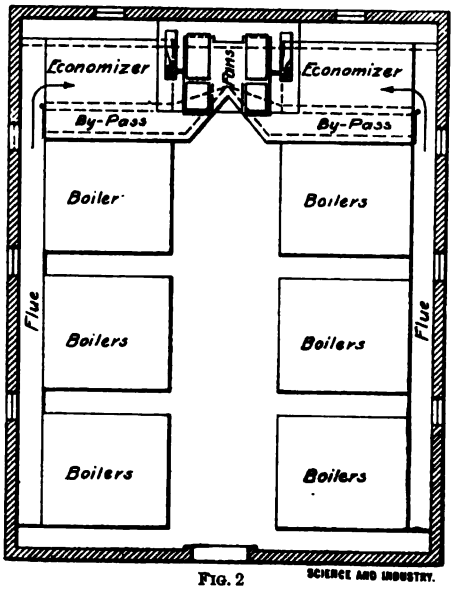

FIG. 2 SCIENCE AND INDUSTRY.

the chimney. This apparatus is of the induced type, designed to draw the gases from the boilers, and in this case to discharge them through a short steel-plate stack extending just through the roof. The general construction of the apparatus is shown in Figs. 3 and 4. It consists of two steel-plate fans, either one of which is capable of producing the draft for the entire plant, and both of which operated together would provide the opportunity for forcing it far above its rating. Each fan is operated by an independent engine, so that either one or both of the fans can be operated at will. Suitable inlet and outlet connections make possible the entire isolation of either one of the fans for cleaning or repairs.

By an automatic arrangement, a very slight change in the boiler pressure very materially alters the quantity of steam supplied to the engines, the effect being that instantaneous changes are made in the draft, and the boiler pressure is maintained practically constant. The entire apparatus is supported in a simple manner on top of the economizer settings.

Evidently this type of apparatus, being duplex in character and handling the heated gases at about twice the volume of the initial air supply, is the most expensive that could be installed. Nevertheless, its total cost, with foundations, inlet and outlet connections, automatic-regulating device, and short stack would be only about $4,700.

The account, therefore, stands as follows:

CHIMNEY DRAFT	
Cost of chimney	$10,200
Cost of damper regulator and dampers	400
Total	$10,600
MECHANICAL DRAFT	
Cost of mechanical-draft plant complete	4,700
Saving by using mechanical draft	$ 5,900

Incidentally there is also saved the space previously occupied by the chimney. The value of this space must of course depend on the location of the boiler plant. If in the heart of a city it may well amount to from $1,000 to $2,000.

Frequently, because of location, the erection of a chimney becomes an excessively expensive undertaking. In a recent instance a large establishment in the retail district of a large city desired to increase the output of its boiler plant. The boilers were located in a sub-basement below water level; the space was restricted between two high buildings, in the corner of one of which was carried the chimney. Estimates on a new chimney of sufficient capacity figured about $7,000, and contemplated supporting it in part above the boilers. The problem was a difficult one to solve, but resort was had to mechanical draft, utilizing the old chimney for the discharge of the gases. The price paid for a complete induced-draft fan and engine was only about $1,200.

The cost of the mechanical-draft plant for the 2,400-horsepower plant as given above was a little over 44 per cent. of that of the chimney and accessories. This compares favorably with the averages of nine different plants, data regarding which have been collected. In certain of these cases the cost of the chimney was known and that of the mechanical-draft plant was accurately calculated. In others the contract price for the mechanical-draft plant formed the basis of

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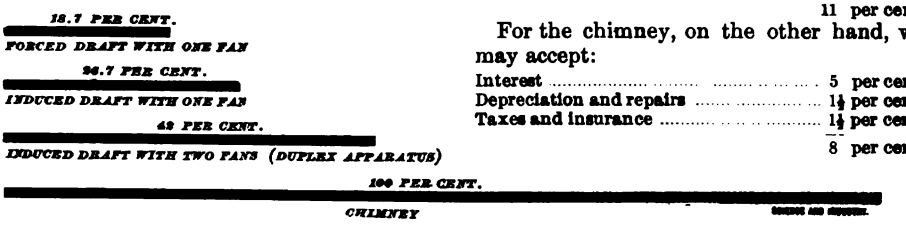
comparison, and the cost of the chimney was estimated. The average relative costs are shown by the lengths of the lines and indicated by the figures given below:



In each case the cost of the mechanical-draft plant included a short steel-plate stack. These averages are sufficiently general in their character (being based on boiler plants ranging from 150 to 2,500 horsepower) to show that under all ordinary conditions the cost of a fan and accessories is far less than that of a chimney of equal capacity.

But it may reasonably be asked, Does not the fan deteriorate more rapidly than the chimney? Most assuredly it does, but under good conditions no more rapidly than the general average of the boiler plant.

In making up our fixed charges it is fair to assume for the mechanical-draft plant:

Interest	5 per cent.
Depreciation and repairs	4½ per cent.
Taxes and insurance	1½ per cent.
	11 per cent.

For the chimney, on the other hand, we may accept:

Interest	5 per cent.
Depreciation and repairs	1½ per cent.
Taxes and insurance	1½ per cent.
	8 per cent

That is to say, 3 per cent. less on the chimney than on the fan. In other words, if a chimney were to cost $10,000, the annual fixed charges would be 8 per cent. of $10,000, or $800. Taking the proportionate cost for different types of substitute mechanical-draft apparatus as previously indicated, the fixed charges on a basis of 11 per cent. would be:

Forced draft with one fan	$206.00
Induced draft with one fan	294.00
Induced draft with two fans	462.00

This still shows evident advantage in cost of mechanical draft.

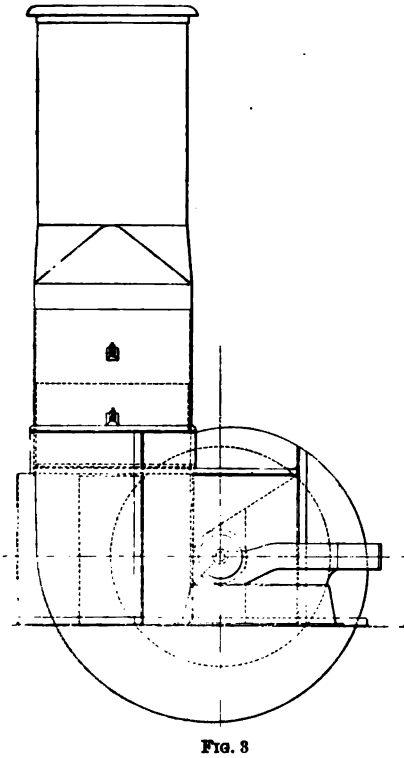


FIG. 3

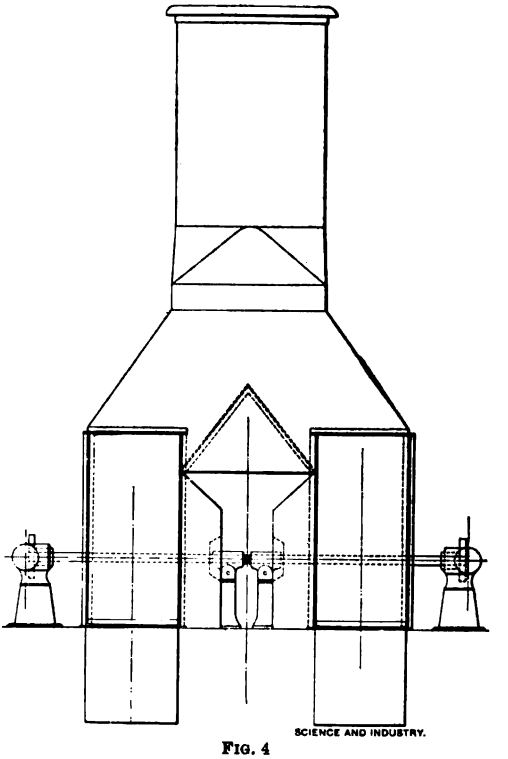


FIG. 4

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One of the important characteristics of mechanical draft is its ability to readily produce pressures of draft in excess of those obtainable with the ordinary chimney. This results in more rapid and intense combustion, and makes possible the forcing of boilers above the limit usual when a chimney is employed for draft production. In other words, a boiler may be increased in capacity.

It is true that with chimney draft, increased output above the rating is likely to be indicative of decreased efficiency of combustion. One of the factors in bringing about lower efficiency is the higher temperature of the gases necessary for the production of greater chimney draft. What is more, the quantity of air supplied with the chimney is frequently excessive and difficult to control. But with the fan, the positive supply of air, its perfect and automatic regulation, and deeper fires, all tend to show as good results under conditions of reasonable forcing as are usually obtainable with a chimney when the boilers are operated at their rated output. If, with these facts in mind, we should take the 2,400-horsepower plant previously under consideration, and omit two boilers and at the same time substitute mechanical draft, the plant would have a rated capacity of only 2,000. This could readily be forced to 2,400 horsepower by means of the fans; and with the economizers remaining the same, would undoubtedly show as good evaporative efficiency as the original plant with chimney draft. But the reduction in the number of boilers, if the plant were to be designed for only 2,000 horsepower, would incidentally bring about a decrease in the cost of the settings and of the building, with the following aggregate results:

2,400 NOMINAL HORSEPOWER PLANT WITH CHIMNEY DRAFT

12 boilers	$37,000
2 economizers	10,500
Boiler and economizer settings, and by-passes	9,000
Automatic damper regulator and dampers	400
Chimney, including foundations	10,200
Boiler house	11,500
Total	$78,600

2,000 NOMINAL HORSEPOWER PLANT WITH MECHANICAL DRAFT

10 boilers	$30,833
2 economizers	10,500
Boiler and economizer settings, and by-passes	8,500
Boiler house	11,000
Mechanical-draft plant complete	4,700
Saving by using mechanical draft	13,067
	$78,600

Of the $13,067 thus shown to be possibly saved by introducing mechanical draft instead of chimney draft, $5,900 has already been accounted for by the mere omission of the chimney, leaving $7,167 as the amount to be credited to the reduction in nominal rating.

Inasmuch as mechanical draft presents, as one of its salient features, the opportunity for utilizing a large proportion of the waste heat of the flue gases, it is in a sense proper that the fan and the economizer should be considered as related parts of a fuel-saving apparatus. Suppose, therefore, in the case of the 2,400-horsepower plant, that it was originally designed for chimney draft without economizers, and that in the introduction of mechanical draft the economizers are installed as incidental thereto.

Viewed in the light of the resultant economy, we may therefore consider that this added expense is the difference between the cost of the chimney and dampers and that of the combined mechanical-draft apparatus and economizers with settings. This appears about as follows:

Cost of mechanical-draft apparatus	$ 4,700	
Cost of 2 economizers with settings	12,500	
		$17,200
Cost of chimney, with dampers and damper regulators		10,600
Extra cost above chimney		6,600

The results of tests of nine plants of this general character show (as reported by Roney) an average fuel saving of nearly 15 per cent. Suppose that we accept only 12 per cent. as attainable and consider that we are burning coal costing $3.00 per ton and evaporating 11 pounds of water from and at 212° per pound of coal. This is equivalent to $34.5 \div 11 = 3.14$ pounds of coal per boiler horsepower. Basing our calculations on an output equal to the rating (2,400 horsepower) and a year's operation (312 days of 10 hours each), the annual fuel cost would be

$$3.14 \times 2{,}400 \times 312 \times 10 \times \frac{3.00}{2{,}000} = \$35{,}268.48.$$

If, in securing this result by the introduction of the apparatus specified, a saving of 12 per cent. has been made, it is evident that the cost of fuel would otherwise have been

$$\frac{\$35{,}268.48}{1.00 - .12} = \$40{,}077.82.$$

Hence, annual saving would be 40,077.82 − 35,268.48 = $4.809.34. In other words, the saving represents $\frac{4{,}809.34 \times 100}{6{,}600}$ = nearly 73 per cent. of the expense fairly chargeable

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as the cost of the means of obtaining it. At this rate, the apparatus would pay for itself in

$$\frac{6,600}{4,809.34} = 1.37 \text{ years.}$$

Of course, there should be charged against this the increased fixed charges due to more rapid deterioration. The cost of operating the fan ought not to enter as a factor of any importance in a plant where the exhaust of the fan engine can be utilized.

The preceding is presented more as a suggestion of possibilities than as representative of exact results to be secured. These, of course, will vary according to the conditions. It should, however, be clearly stated and understood that the efficiency obtainable with an economizer depends on the temperature of the gases leaving the boilers and on the cost of the fuel. The lower the temperature and the smaller the cost of the fuel, the less opportunity there will be for saving.

It is evident, however, that in the ordinary plant—where the size warrants—the installation of mechanical draft in connection with some suitable device for heat abstraction opens the way for securing increased quantitative and commercial efficiency.

DESIGNING MACHINERY

D. Petri-Palmedo

PERMISSIBLE STRESS—THE PRINCIPLES FOR A SCALE OF SAFE STRESSES—LIMITS—DEAD AND LIVE LOADS—REVERSIBLE LOADS—WÖHLER'S RATIOS

PART V

THERE is a period in the life of every young machine designer when he feels utterly wretched and helpless and hopeless. This is the time when he is first asked to calculate the dimensions of the various details of a design for strength. He will go at it, perhaps, with a light heart, conscious of his knowledge of mechanics of materials, of Hooke's law and the long array of formulas derived from it for tensile, compressive, bending, shearing, and twisting stress. However, as soon as he starts to apply these formulas he is confronted with the question: How much stress can I allow for the various materials? Then the never-ending hunt begins for values of that everlastingly recurring symbol S, the permissible or working stress. He will go and ask his superior that question and feel dejected at receiving the evasive answer: "That depends on circumstances," followed by an enumeration of some of the circumstances, such as quality of material, character of the load, function of the detail part, friction, wear, influence of temperature, cost of material, cost of manufacture, facility of transportation, of erection, and—many others. The querist pauses. Realizing that there is no short answer to his question, he must needs be content to ask for the lesser information, pointing to the details under immediate consideration: "How much stress would you allow for these pieces?" The answer, though given promptly enough, may vary between large limits for the same material and the different pieces, according to what use they are put. The mystery of the thing, for such it seems and such it remains for many all their lives, is deepened when one consults the authorities and finds that hardly two of them agree on the subject of working stresses. As a matter of fact, permissible stresses are largely dictated by experience, and no definite rules can be given. This is disheartening and apparently makes our splendid formulas of dubious value and their application mere guesswork after all, as each of them contains an element that must be guessed at—the S of practical experience. The non-mathematical practical man is wont to advance this as an argument, and guessing, with thumb on the foot rule, at the whole thing at once, thus eliminating the necessity of calculation, claims to be one peg ahead of us.

This state of affairs is, however, not altogether so bad as it looks, for, fortunately, for many years busy workers have been collecting data and sifting and arranging them, thus establishing a fairly firm ground for the designer to stand on, which ground is growing more stable every day, thanks to the fast-increasing hearty cooperation of the men of science and the men of practice. Nevertheless, the mass of information that really exists on the subject of permissible stresse

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is widely scattered, and one seldom finds in engineering pocketbooks and manuals such systematic arrangement of the matter as will be of immediate use to the beginner in machine design. With a view of furnishing some such immediately useful data, we shall outline in the following the principles upon which a collection of useful data should be arranged. These principles (although at present there are no laws absolutely governing this matter) serve to establish, with a high degree of certainty, standards for working stresses.

Evidently, the first requirement is as perfect a knowledge of the physical properties of the materials as can be obtained. Of information of this kind there is no scarcity, thanks to the great number of physical testing laboratories maintained in all civilized countries. The particular property of a material that comes into play for the establishment of standard working stresses is that one by virtue of which a body made of such material undergoes certain deformations under the influence of external forces. Evidently, the extent of these deformations will primarily depend on the magnitude of the external forces, and the latter becoming large enough will result finally in rupture of the body, the resistance of the body by the cohesion of its molecules becoming less than the external forces. It is well known that the deformation undergone by a body under load is of a twofold character.* A portion of it will disappear on the removal of the load, the rest will remain, and the body will recover its original shape more or less. This power of recovery from deformation is called *elasticity*, and is a property possessed by the various materials in a greater or lesser degree, according to the ratio between the part of the deformation that disappears (the elastic deformation) and the part that remains (the permanent deformation). This proportion with all materials is found to be larger under small loads and smaller as the loads increase. It becomes zero when the load is great enough to produce rupture. With some of the materials used by the engineer—iron, steel, brass, rolled or hammered copper, and timber—the permanent deformation is insignificantly small up to a considerable magnitude of the load, and the elastic deformation proves proportional to the load within this limit, which is, therefore, appropriately called the *limit of proportionality*. It might, with equal justification, be called the limit of elasticity, but as this latter term is, in practical testing, often applied to the yield point of materials, we prefer the other term.

The statement that the deformations are proportional to the loads, and consequently to the stresses produced in the material by the loads, is known as Hooke's law, upon which rests the whole theory of mechanics of material. This law holds good, as we have seen, only within the limit of proportionality, so that beyond that limit, and with materials that have no limit of proportionality—for there are such—the conclusions from Hooke's law need more or less modification. Such materials are, for instance, cast iron, unrolled or unhammered copper, lead, leather, etc.

Having recalled to our mind the behavior of material under the testing machine, we see that the disintegration of the molecules begins, strictly speaking, at the very commencement of the test, and is made discernible and measured by the amount of permanent deformation observed. Evidently, the elastic deformation does not in any way injure the material in the least. Thus, at once, it appears logical that if the material have a limit of proportionality, the limit up to which no appreciable permanent deformation is observed marks the real strength of the material. Safe stresses should, therefore, always lie within this limit. Any increase of stress beyond it from whatsoever cause will injure the material and render a structure made from it unsafe. But of such causes there are many, foreseen and unforeseen, and we dare not approach this limit of load too closely—how closely depends on the load-increasing causes likely to exist, and their number, nature, and effect.

Let us review some of the principal ones. There is, first of all, the mode of application of the load. Theoretical mechanics teach us that when a load is suddenly applied its effect is double that of a load gradually applied. To avoid misconception as to what the term "suddenly applied load" implies, let us take recourse to an illustration. Imagine a stone or other heavy body touching but not resting on the end of an upright post, the stone being supported from above by a rope. The load on the beam is zero. The moment the rope is cut the weight rests on the beam, and now the following action may be imagined to set in: The weight will first produce pressure between the stone and the particles, or molecules, at the surface of the post end, compressing these particles;

* See "The Mechanic Arts Magazine," May and June, 1899, article entitled "The Testing of Steel."

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this pressure will be communicated to the particles just below the surface particles, compressing these again, to which end the first particles, together with the stone, must travel a distance equal to that compression; next, the pressure is communicated to a third layer of particles, compressing these again, and the stone, together with the first and second layers of particles, must move a distance equal to the compression of the third layer, and so forth. Although the distances traveled are exceedingly small, the time during which they are traveled is exceedingly small also. The velocity that is acquired by the mass composed of the stone and various layers of post particles may be considerable by the time the pressure or stress has permeated the whole post; this velocity makes the kinetic energy acquired likewise considerable, adding its effect to that of the original weight; the total effect is, as already stated, double that of the weight alone. On the other hand, if the load were put on the end of the post in the form of sand, for instance, adding a few grains at the lapse of considerable intervals of time, the accumulations of kinetic energy would amount to nothing.

Such is the nature of a gradually applied load. Neither one purely exists in practice, but it is safe to say that the majority of dead loads come nearer to being suddenly applied loads than gradually applied ones in the above sense, and we may lay down as the first principle for establishing standards of working stresses that *for dead loads the safe stress should not exceed one-half the real strength of the material.*

Let us again go back to the illustration of the stone and post. Imagine that after the permeation of the stress has proceeded as far as the center of the post, the stone is suddenly snatched up; then the end-surface particles of the post are relieved from stress, expand, travel up, and those of the layer just underneath follow, acquiring and accumulating energy. All the while the accumulation of energy by the particles beyond the center of the post has been going on in the other direction. It can thus be imagined that there will be a moment when the two opposite effects will exert a combined maximum effect on some layer of particles within the length of the post, which effect will be greater than that of the previous case.

Wöhler, by experiments covering a period of over twelve years, has shown that the strength of materials under loads varying continually between zero and maximum—so-called live loads—is only two-thirds as great as that under dead loads. We have then the second principle that *for live loads the safe stress should not exceed* $\frac{1}{2} \times \frac{2}{3} = \frac{1}{3}$ *the real strength of the material.*

Once more we will revert to our illustration. Suppose the stone to be substituted by some contrivance by which the post may be pressed or pushed to the same extent as by the weight of the stone; now, instead of snatching up the stone and thus removing it from the sphere of action entirely, suppose the contrivance is such that a pull could be exerted on the end of the post equal to the push previously applied. In this case the counteraction spoken of in the last case is greatly aggravated. It has been shown by experiments conducted by Wöhler, and others after him, that the strength of materials under loads changing from a positive to an equal negative maximum—so-called reversible loads—is only one-third of that of material under dead loads. Thus, we may lay down the third principle, that *for reversible loads the safe stress should not exceed* $\frac{1}{2} \times \frac{1}{3} = \frac{1}{6}$ *the real strength of the material.*

The three principles so far told may be laid down in one, as follows: The working stresses under the conditions of (1) dead load; (2) live load, zero to maximum; (3) reversible load, negative to equal positive maximum, should be as $\frac{1}{2} : \frac{1}{3} : \frac{1}{6}$ or as 3 : 2 : 1. It is clear that intermediate cases may be imagined between the extreme conditions (1), (2), (3). Thus, if for a certain material we have fixed upon a value of 12,750 pounds for case (1) and one of 8,500 for (2), we would choose a value half way between the two, if the load were not altogether a dead load, neither changing between zero and maximum, but changing between half load and full load.

Other causes tending to increase the load as originally given are vibrations, shocks, and other like indeterminate conditions, and excessive changes of temperature. Others, again, must be seen in neglect, allowing the structure to deteriorate by corrosion or rust. For all these contingencies the designer must allow a smaller permissible stress, according to how important they appear to his judgment in each case; nothing but data from practical experience can be of help to him in such cases.

We started out on the assumption that the limit of proportionality of deformation could be established for the materials in question. We have not mentioned as yet, however, that the deformation of a body, or

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more especially of a particle of a body, may be of either of two kinds. Imagine the particle of a body to have the shape of a cube; then, if two equal and opposite forces press against or pull on two opposite surfaces of this cube, they will shorten or lengthen it and the deformation is one of extension or compression in the direction of the acting forces, and for all such materials that show a distinct limit of proportionality, extensions and compressions are equal under equal loads. Incidentally we observe that every such extension or compression is accompanied by a contraction or expansion, respectively, of the material at right angles to the direction of the forces. These secondary deformations, if we may call them thus, stand to the primary ones in a certain ratio.*

Again, imagine the cubic particle to be acted on by two equal and opposite forces lying in the planes of two opposite surfaces of the cube, then there must first of all be two more equal and opposite forces acting somewhere to keep the cube in equilibrium. Disregarding the latter pair for the present, the former one will change the shape of the particle from that of a cube to that of a prism with quadratic end surfaces on which lie the acting forces. Two of the other four surfaces become rhombi. There has then been a double deformation: in the direction of the short diagonals of the rhombi there has been compression, and in the direction of the long diagonals, extension. If we imagine the second pair of forces to lie in the two remaining surfaces of the cube, they will tend to produce a like effect. By a certain theory, the double deformation of the second class can be brought into connection with the secondary deformation of the first class, which fact is a most valuable

*Compare article entitled, "The Testing of Steel," mentioned elsewhere.

TABLES FOR PERMISSIBLE STRESSES

I. Elastic Metals

Material.	Limit of Proportionality.	Tension, Compression, Bending.			Shear.			Torsion.		
		1	2	3	1	2	3	1	2	3
Wrought iron	25,000	12,700	8,500	4,200	10,000	6,800	3,400	5,000	3,400	1,700
Bessemer structural	32,000	16,000	10,600	5,300	12,800	8,500	4,200	8,500	5,000	2,800
Machine steel	36,000	18,000	12,000	6,000	14,400	9,600	4,800	14,400	9,600	4,800
Crucible, open hearth	40,000	20,000	13,300	6,600	16,000	10,600	5,300	16,000	10,600	5,300
Steel castings	25,000	12,700	8,500	4,200	10,000	6,800	3,400	10,000* to 5,000	6,800* to 3,400	3,400* to 1,800
Copper, hard rolled, hammered, drawn†	16,000	8,000	5,300	2,600	6,400	4,200	2,000	6,400	4,200	2,000
Brass, hard rolled, drawn	16,000	8,000	5,300	2,600	6,400	4,200	2,000	6,400	4,200	2,000
Phosphor bronze, aluminum bronze, and similar alloys, cast	20,000	10,000	6,500	3,300	8,000	6,400	2,600	8,000* to 4,000	6,400* to 3,200	2,600* to 1,300

II. Cast Iron

Breaking Strength.	Tension.			Compression.		Bending. Machined.			Bending. Raw.			Shear.			Torsion.		
	1	2	3	1	2	1	2	3	1	2	3	1	2	3	1	2	3
Tension 20,000	4,200	2,800	1,400	12,700	8,500	8,700	5,800	2,900	7,200	4,800	2,400	4,200	2,800	1,400	4,200	2,800	1,400
						7,200	4,800	2,400	6,000	4,000	2,000				3,400	2,200	1,100
Compression 112,000						6,000	4,000	2,000	5,000	3,400	1,700				6,000	4,000	2,000
															6,800	4,500	2,200

*The smaller values are recommended when precautions for absolute uniformity of material against blowholes, etc. cannot be guaranteed.

†The critical temperature of hard-rolled, etc. copper is in the neighborhood of 400° F. Above this temperature the material rapidly decreases in strength.

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one, inasmuch as deformations of the first class can be determined by test with a sufficient degree of accuracy, while the latter cannot. These are, however, such as occur in bodies under shear and torsion, while those of the first class occur in bodies under tension, compression, and bending. As the deformations again are within the limit of proportionality, proportional to the stresses producing them, we can deduce the permissible, working, or safe shearing or torsional stress from the permissible tensile or compressive stress. Theory shows the ratio for the conversion to be four-fifths, very nearly. Thus we would have for the safe shearing stress of a material four-fifths of the safe tensile or compressive stress in all cases where there is a limit of proportionality.

As to the torsional stress, although it is nothing more than shearing stress, it must be borne in mind that it stands to shearing stress proper in somewhat similar relation as tensile and compressive stress stand to bending stress; that is, it is not as evenly or nearly as evenly distributed. If there is any possibility of the material not being homogeneous or of even texture in all directions, its resistance in one direction against torsional stress may not be as great as in another. This is the case with wrought iron obtained by the puddling process—for instance, having a more or less fibrous texture. Likewise, but not to such a marked degree, with structural steel as it comes from the rolls. The more homogeneous a material, the more nearly equal the safe torsional stress may be made to the safe shearing stress. For distinctly fibrous material it is not safe to allow more than one-half, for rolled raw material not more than two-thirds.

From the foregoing principles Table I has been prepared for the most important metals used in machine building that have an elastic limit. Table II gives the permissible stresses of cast iron, the most important metal in the group of materials showing early permanent deformation. It is based solely on data from practical experience. It will be noticed that for bending and torsion the shape of the piece makes considerable difference. Timber and stone enter but little into machinery proper in our day, for which reason we deem it sufficient in this necessarily limited article to state that the average permissible stress for the softer grades of timber should not exceed 800 pounds per square inch for tension and compression; for the harder and tougher grades 1,500 pounds for tension and 900 pounds for compression. Sandstone will be safe under a compressive stress of from 225 to 450 pounds, according to hardness. Marble will safely stand 350 pounds. Poor brickwork (ordinary mortar) should not be loaded with more than 100 pounds. Brick laid in cement will safely stand 170 to 200 pounds.

THE THREE LAWS OF MOTION

By the "Professor"

THE fundamental principles of the relations between force and motion were first stated by Sir Isaac Newton, and in honor of the discoverer, they are called "Newton's Three Laws of Motion." They are as follows:

1. All bodies continue in a state of rest, or of uniform motion, in a straight line, unless acted on by some external force that compels a change.

2. Every motion or change of motion is proportional to the acting force, and takes place in the direction of the straight line along which the force acts.

3. To every action there is always opposed an equal and contrary reaction.

It is not possible to actually verify the first law of motion by direct experiment, on account of the attraction of the earth for all bodies; but from astronomical observations we are certain that the law, which is often called the law of *inertia*, is true. From the second law it follows that, if several forces act on a body, their final effect on the body will be in proportion to their magnitudes and to the directions in which they act. This can readily be verified by direct experiment. The third law states that action and reaction are equal and opposite. A man cannot lift himself off the ground by his boot straps, for the reason that he presses downward with the same force that he pulls upward; the downward reaction equals the upward action, and is opposite to it.

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SERIES INCANDESCENT LAMPS FOR STREET LIGHTING

R. B. Williamson

DESCRIPTION OF CIRCUIT—STYLE OF LAMPS—THE METHOD OF REGULATION—FILM CUT-OUT. BRACKETS—REGULATING DEVICES

IN MANY small towns it is desirable to operate incandescent lamps for street illumination, and even in cities they are often very useful for lighting out-of-the-way places that do not require an arc lamp. Incandescent lamps are, however, specially useful in small towns where it would not pay to put in a separate arc-light outfit. Most of these incandescent plants are operated by alternating current, either at 1,000 or at 2,000 volts, and it is necessary to have some system for street lighting that may be readily adapted to such voltages. Of course, the lamps might be operated at 50 or 100 volts from the secondaries of transformers in the ordinary way, but this would hardly be practicable for street lighting, because the lamps are so widely scattered that the cost of the secondary wires would prove a serious item. The method generally adopted is, therefore, to use a special kind of incandescent lamp, and operate these lamps in series directly across the 1,000- or 2,000-volt dynamo, as the case may be. This method is shown in outline in Fig. 1. *A* is the alternator, generating, say, 1,000 volts. The lamps used for ordinary illumination, such as for residences, etc., are connected through transformers, as shown at *B*. The street-lighting circuit consists of a number of incandescent lamps *l*, all connected in series and cut in across the mains at *a*, *b*; the point *b* may be at the station or on the line, whichever is the more convenient. In order that such a series system may work successfully, the current in the circuit must be kept at a certain value, for which the lamps are designed. It is also evident that there must be a sufficient number of lamps connected in series to take up the voltage of the dynamo. For example, if each lamp required 20 volts, there would necessarily be 50 lamps connected in the circuit, unless some outside device, such as a resistance or choking coil, was used to take up the extra voltage. A very common arrangement is to use 50 lamps on a circuit, each lamp giving about 20 or 25 candlepower and requiring a current of 3½ amperes. Lamps giving a higher candlepower, but using the same current with a higher voltage, could also be run on the same circuit. A current of 3½ amperes seems to have become the ordinary practice for such circuits; and, in order to carry this comparatively large current, the lamps used for this purpose have short thick filaments. Sometimes a current of 5½ amperes is used, thus allowing the use of a lower voltage per lamp and a larger number of lamps per circuit. The lamps of higher candlepower would have longer filaments, but would be designed for the same current, so that they could be operated in circuit with lamps of lower candlepower.

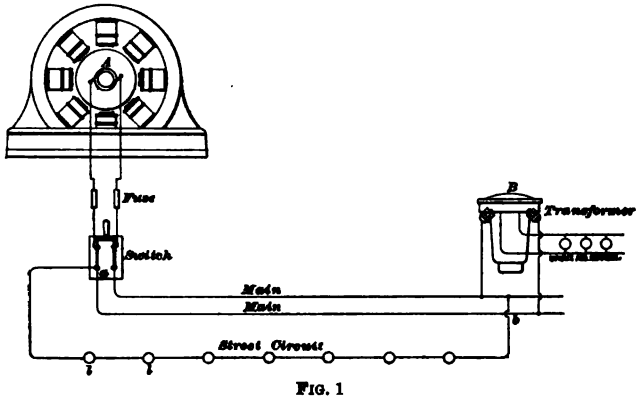

FIG. 1

Fig. 2 shows the type of lamp with thick filament used for this system of lighting. It is essential, in such a system, that the current be kept uniform. If it increases, even slightly, the lamps are liable to be damaged; and if, on the other hand, it drops a little below the normal amount, the light will be very poor. It is clear, then, that the simple scheme of connections shown in Fig. 1 will not answer, because it affords no means for regulating the current. Provision must

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also be made to keep the circuit complete, in case one or more of the lamps should burn out, otherwise all the lamps on the circuit would be put out.

In order to keep the current at the same value, a few additional lamps are mounted on the switchboard in the station, and are arranged with a point switch so that they may be cut into or out of the circuit at will. In case a light on the circuit happens to go out, one of these reserve lamps may be cut in to take its place, thus keeping the resistance of the circuit constant, and with it the current. In order to tell when the current is at its proper value, an ammeter is inserted in the circuit, and when the current is at just the right amount, the pointer stands at a mark about the middle of the scale; if one or more lamps go out, it moves past the point, and the station man cuts in lights till it comes back again.

FIG. 2

Fig. 3 shows the general arrangement of one of these lamp boards, which are made to accommodate different numbers of lamps, depending on the number of lights run on the circuit. In this case six lamps *l* are shown; *a* is the ammeter and *s* the switch for cutting the lamps in or out. Cut-outs are placed across the switch contact points, in order to allow lamps on the board to be removed or changed without breaking the circuit. These cut-outs are not shown in the figure, as they would only tend to confuse it, but they work in the same way as those to be described later in connection with the lamps. These lamp boards differ slightly as to details, but Fig. 3 will give a general idea as to the necessary parts, together with their arrangement and method of operation. It is necessary to have one of these controlling lamp boards for each series circuit operated, and in case there are not enough lamps on the circuit to take up the voltage of the machine, additional ones must be used on the board to make up the difference. This method is very wasteful, but nevertheless it has been largely used in the past and is still used in many places.

Mention has already been made of the necessity of keeping the circuit unbroken in case a lamp should burn out. A number of different arrangements have been used to accomplish this. One method is to use a small kicking coil mounted in the iron base to which the lamp bracket is attached, and connected across the terminals of the low-voltage lamp. In case the lamp breaks, the impedance or kicking coil takes its place; but while the lamp is in operation, only a small current passes through the choke coil. The most common method, however, is to use what is known as a *film cut-out* on each lamp. The action of a cut-out of this kind will be understood by referring to Fig. 2, where the lamp represents one of the

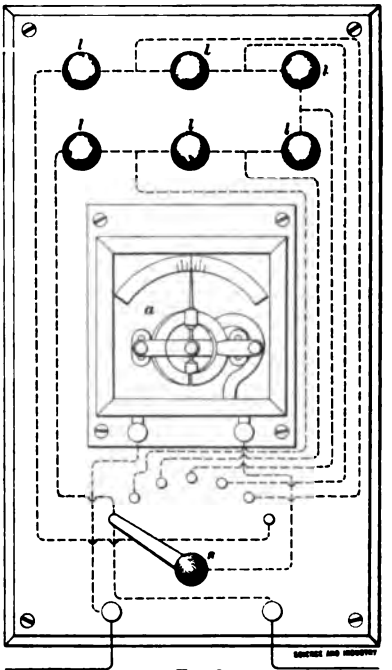

FIG. 3

series connected across a 1,000-volt alternator. To the terminals of the lamp are attached two springs *a*, *a'*, which are held apart by a thin piece of paper *b*. As long as the lamp is burning properly, the difference of potential between its terminals is, say, about 20 volts. As soon, however, as the filament breaks the current ceases flowing for an instant, and the result is that the pressure between *a* and *a'* instantly rises to that generated by the dynamo,

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because the drop in pressure through the circuit becomes zero as soon as the current ceases flowing. The film of paper is capable of withstanding the 20 volts necessary to operate the lamp; but, as soon as the pressure rises to that of the alternator, it is at once punctured, thus completing the circuit around the lamp by means of springs a, a'. In practice, there is but one contact spring, and this is mounted on the base of the lamp, the paper film being held between this spring and the other base terminal. Fig. 4 shows an end view of a lamp base with the paper film b in place under the spring clip. In some cases the film cut-out is placed in the lamp socket, but this is seldom done with street lamps, because the socket would be hard to get at to renew the film.

FIG. 4

Lamps operated on this system are usually mounted on iron brackets, as shown in Fig. 5. It was formerly the custom to bring the lead wires out from the pole through the gas-pipe arm, but it is better to bring them down to a small cross-arm, as shown, and carry them into the fixture just above the hood. This does away largely with the danger of the wires becoming grounded in the pipe. It pays to put these fixtures up well; they are not expensive, and there is no excuse for cheap flimsy work on lighting circuits of this character. Only the best style of lamp socket should be used, and care should be taken to see that everything about the wiring of the brackets is perfectly insulated. The fact that a system of this kind is connected directly to a high-tension alternator should never be lost sight of, and all the line work should be as carefully carried out as if it were for the primary mains used to feed the transformers. These brackets, or *goosenecks*, are nearly always fitted with a water-tight hood and enameled reflector, as shown in Fig. 5. Sometimes, to protect it from dirt and injury, the lamp is shielded by an outer globe; but in many cases the lamps are operated without this precaution, since the outer globe always cuts off more or less light.

The series incandescent system just outlined is one that has been used very largely, and has been found of great use for street illumination from alternating plants. It requires little or no outlay in additional plant appliances, and it requires no transformers for its operation. The line work is the simplest that can be devised, and it is therefore little to be wondered at that the series alternating incandescent system has found a wide field of usefulness. The apparatus that has been described in this connection has, however, some defects. The use of lamps as a resistance in the station is, to say the least, extravagant, especially when it is remembered that these lamps are burned up to their full candlepower. Not only are they wasteful in that they consume power, but the lamps are, in themselves, an expensive form of resistance. The arrangement has been given because it has been installed, and is still used, in a large number of stations; and at least this much can be said for this method of regulation: its first cost is low, even if it does waste power while it is in use, and moreover it is so extremely simple that it is certainly reliable. This method of operation was put largely into use by The Thomson-Houston Company, and The Westinghouse Company also installed a similar system, using kicking coils instead of the film cut-outs in connection with the lamps. During later years, regulating arrangements have been brought out that accomplish the governing of the system without the use of auxiliary lamps and also with very little waste of power. Moreover, these later regulating devices allow a large variation in the voltage applied to the circuit, so that it is possible to operate circuits that are equipped with a number of lamps differing considerably from that which the machine would ordinarily operate. A description of one of the latest of these regulating boards will be given in a subsequent issue of this magazine.

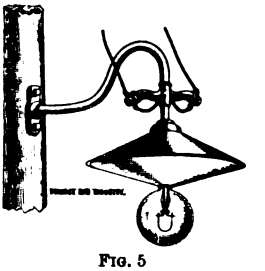
FIG. 5

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THE FLOATING VALVE GEAR

J. A. Grening

DEFINITION OF FLOATING VALVE GEAR—ITS APPLICATION TO STEAM REVERSING GEAR. TWO TYPES OF STEERING ENGINES

IF A stationary engineer, accustomed to the ordinary stationary steam-plant practice, were to visit the engine room and fireroom of a modern up-to-date steamship, he would, if he possessed, as he should, "eyes that can see," observe many things differing quite a little from established practice in stationary engineering. While it cannot truthfully be said that the points of difference are always in favor of the marine practice, and could and should with advantage be adopted in stationary engineering, a technically educated visitor will, if he is at all observant, be favorably impressed with the care bestowed by the designer of the power plant of a steamship on details that facilitate the handling and maintenance of the machinery aboard ship, and will probably wish that the designer of the ordinary steam plant ashore would use an equal amount of care. He will also find many devices that are never heard of in stationary work, such as evaporators for making fresh water for the boilers; distillers for making the fresh water made by the evaporator fit for drinking purposes; an engine for turning the main engines when overhauling them in port; perhaps he may even find a hydropneumatic ash ejector that removes the ashes from the fireroom with a minimum of labor on the part of the attendant. Walking around the engines he will find that, if they are at all large, they are supplied with steam reversing gear, and, should he be fortunate enough to be in the engine room on sailing day, and shortly before the appointed sailing time, he would marvel at the ease with which the engineer on watch is moving the ponderous links back and forth while warming up the engines. He sees the engineer move with one hand, with the greatest ease, a lever looking small in comparison, and sees the links follow the motion of the lever, stopping when the lever stops and reversing when the motion of the lever is reversed. Watching them closely, he will see that they move rapidly when the lever is moved rapidly, and, conversely, they will move slowly when the reverse lever is moved slowly. Now, let the stationary engineer become a cabin passenger, and let him gaze into the pilot house while at sea. He will see the quartermaster at the steering wheel, which is a comparatively small looking affair. As the quartermaster rotates his little wheel with no apparent effort, the passenger will notice the big ship swinging to port or starboard, according to the way the steering wheel is turned. Now let the passenger repair to the main deck. Right below the pilot house he will find an engine of peculiar construction, connected to the wheel in the pilot house. He will notice that the steering engine commences to turn as soon as the quartermaster turns the wheel; he will see it stop when the steering

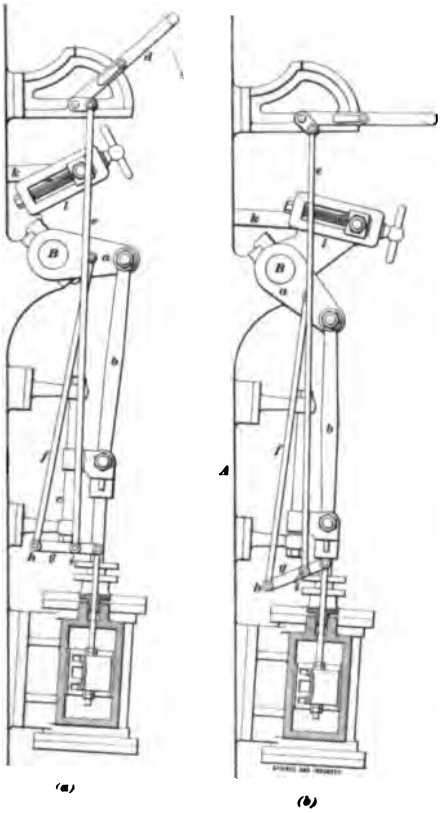

FIG. 1

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wheel stops, and turn in an opposite direction as soon as the steering wheel is rotated opposite to its former direction of rotation. As this is entirely due to the peculiar construction of the valve gear, a construction

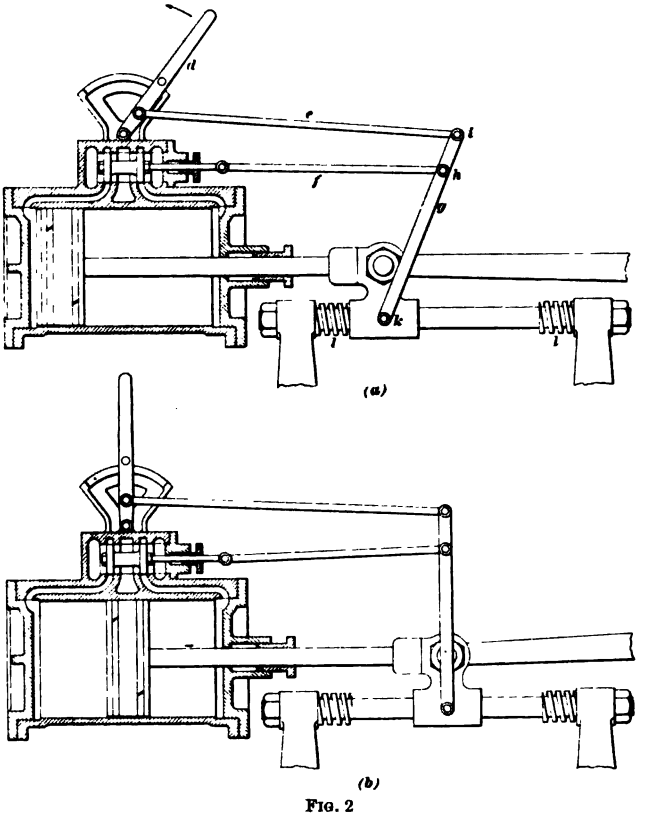

FIG. 2

very little known outside of marine work, it is believed that a description of it will prove of interest to steam engineers.

The valve gear employed on steering engines and steam reversing engines belongs to a class known technically as a *floating valve gear*. Broadly speaking, a floating valve gear is a gear so constructed that the motion of some part of the engine, induced by a displacement of the valve by means *independent* of the engine, will automatically return the valve itself to its original position and thus stop the engine.

As a matter of course, there are many combinations of the elements of machines that may be devised to accomplish this object, but only some of those in most common use aboard ship will be given here; and as a study of them will serve as food for thought and perhaps reveal uses to which they may be put with advantage in work ashore, the object of this article will have been accomplished.

In Fig. 1 the steam reversing gear of a vertical inverted marine engine is shown. In the illustration, *A* represents one of the columns, on top of which the cylinders are carried. The links (the engine having link motion) are connected to crank-arms *l* keyed to the rocker-shaft *B*, there being one crank-arm for each link. By rotating the rocker-shaft, the links may be placed in any position from full gear ahead to full gear astern. To allow the cut-off in each cylinder to be adjusted independently, the reach rod *k* is pivoted to a block, which may be moved along the slot in the upper end of the crank-arms, and clamped in any position. Another crank-arm *a* is also keyed to the rocker-shaft, and connected to the crosshead of a steam ram by the rod *b*. This steam ram is simply an ordinary steam cylinder fitted with a piston and supplied with an ordinary D slide valve practically without lap. The guide bar *c* guides the crosshead in a straight line, and the brackets carrying the guide bar limit the travel of the piston. The reverse lever *d* is pivoted to the center of a quadrant, and can be clamped to the circumference of it in any position between its two extreme positions. The reverse lever is connected by the rod *e* to the floating lever *g*, which is hinged at one end to the valve stem, and at the other end, that is, at *h*, to the rod *f*, which in turn is hinged to *a*.

Whenever the reverse lever *d* is at rest and steam is turned on the valve chest of the ram, the piston and the rest of the gear is in a position depending only on the position of the reverse lever. In Fig. 1 (*a*) the gear is shown in the position occupied when the links are in mid-gear. Now let the lever *d* be moved a short distance in the direction of the arrow. Then, the ram being stationary at first, the floating lever *g* turns around *h* as a fulcrum, being forced to do so by the downward

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movement of *e*. This downward movement depresses the slide valve and opens the upper steam port, putting the lower steam port in communication with the central port, which serves as the exhaust port. Steam being admitted to the upper side of the piston, it descends, carrying with it the crank-arm *a*, and also the crank-arms *l*. The rod *f* being attached to *a* and the reverse lever being at rest, the downward motion of *a* causes the floating lever to swing about *i* as a fulcrum, thus moving the valve in a reverse direction from that in which it was moved originally. This closes the upper steam port and stops the motion of the ram. The valve is always ram remained stationary, any continuation of the movement of the lever would simply force the valve farther downward. But the downward motion of the ram causes an upward motion of the valve, and as a consequence of the combination of these two opposite movements, the valve itself practically remains at rest, and also remains open. But as soon as the motion of the reverse lever is stopped, the onward motion of the piston immediately closes the upper steam port. Any reverse motion of the reverse lever causes an opening of the opposite steam port, and consequent motion of the piston in an opposite direction.

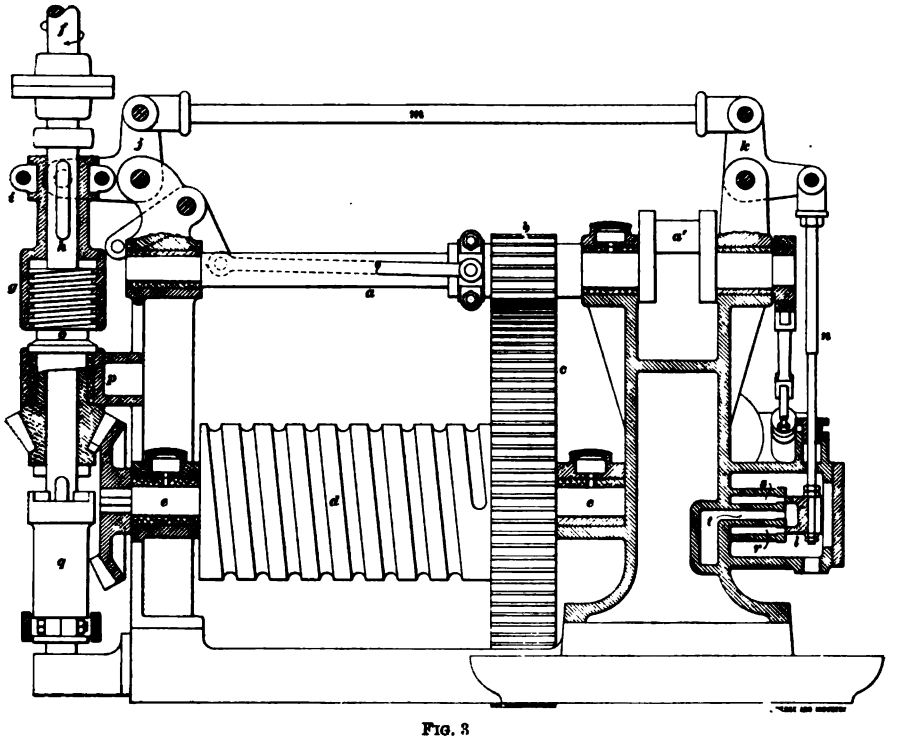

FIG. 3

in its mid-position when steam is turned on and the reverse lever is at rest, for as soon as the lever is brought to rest the onward movement of the piston returns the valve to its original or mid-position.

So far we have investigated the gear on the assumption that the reverse lever was moved just a little distance and then stopped. Now, let us see what will happen if we move the reverse lever slowly toward its lowest position, as shown in Fig. 1 (*b*). In the same manner as before, the first movement of the lever opens the upper steam port, and if the

While steam is turned on, it is not possible for the piston to creep to any extent under the influence of the vibration of the engine or a leaky valve. The links being in the desired position, the reverse lever is clamped to the quadrant, say in the position shown in Fig. 1 (*b*). Now, suppose that due to some cause the piston commences to creep upward. As soon as it commences to move, the rod *f* also moves upward and swings the lever *g* around *i*, thus depressing the valve and opening the upper steam port slightly. Live steam flowing in through the upper

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steam port immediately returns the piston to its original position. Should the piston creep in the opposite direction, it will likewise be returned automatically. Sometimes a clamping screw is provided for clamping the crosshead to the guide bar, thus obviating the necessity of keeping steam turned on to prevent creeping.

A somewhat different arrangement of a floating valve gear as applied to a steam ram used for reversing a marine engine fitted with a so-called radial valve gear, is shown in Fig. 2. The floating lever g is here connected to the crosshead at k. The rod f is hinged at h to the floating lever, and connects it with the valve stem. The rod e is hinged at i to the floating lever, and connects it with the reverse lever d. With the valve gear of the main engine in full gear, the ram is in the position shown in Fig. 2 (a). Let the reverse lever be moved in the direction of the arrow. Then, the piston being stationary, the floating lever swings around k as a fulcrum, and the valve is forced to the left. This valve is an indirect valve, that is, it takes steam at the center and exhausts past its outside edges—just the reverse of the ordinary D slide valve. Then, the valve moving to the left, steam flows through the left steam port and forces the piston to the right. The lower end of the floating lever moving with the crosshead, it tends to swing around i and thus return the valve to its mid-position. Naturally, the left steam port can only be kept open by keeping the reverse lever in motion in the direction of the arrow, for, as soon as its motion is arrested, the onward motion of the piston will almost immediately return the valve and thus stop the ram. In Fig. 2 (b) the parts of the reversing gear are shown in mid-position. It is seen that while the parts of the floating gear have assumed an entirely different position than they occupied in Fig. 2 (a), the valve position is the same. Should the piston creep in either direction, the valve gear will automatically return it to its proper position. To prevent shocks due to a sudden movement of the reverse lever, buffer springs l, l are sometimes provided, which gradually bring the moving parts to rest.

In both gears shown, suitable stops in the valve chest prevent the valve from being moved beyond the positions required for a full opening of the ports.

An entirely different floating valve gear is that shown in Fig. 3. This gear was designed and patented by Mr. Walter Miller, and is used in the Globe steam steering engine for controlling the engines. Referring to the figure, f is a vertical shaft leading to the pilot house and connected by bevel gears to the steering wheel. This shaft carries an internally threaded sleeve g, which is free to move along the shaft, but forced to rotate with it by the feather h. The sleeve is screwed over the so-called hunting screw o, which is loose on the shaft and confined vertically by the bearing p, in which it is free to turn. The lower part of the hunting screw forms a bevel gear meshing with another bevel gear keyed to the drum shaft c. This drum shaft carries the drum d, around which the tiller rope is wound; it also carries the gear-wheel c meshing with a pinion b on the crank-shaft a. A pair of engines at right angles to each other are coupled to the crank a'. The upper part of the sleeve g is grooved to receive the yoke i, which carries a stud on each side; the studs engage one arm of a pair of bell-cranks j. Owing to the view taken, only one of these bell-cranks is shown. The bell-cranks j are connected to two bell-cranks k by a rod m placed between them. The valve stem n is hinged to the two bell-cranks k. At its lower end it carries the so-called change valve l, by means of which steam may be admitted to either one of the steam ports s and r leading to both engines.

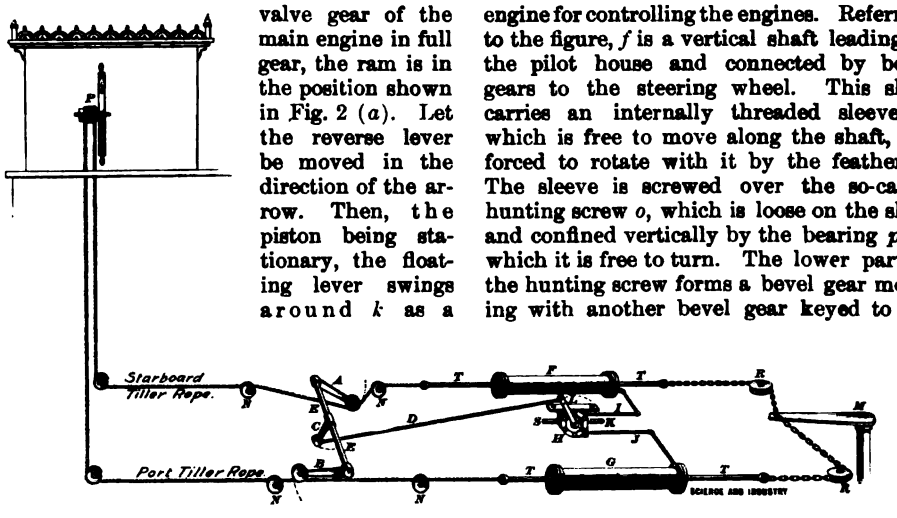

FIG. 4

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The exhaust passage *t* connects with the engines only through the valve *l*.

Let the shaft *f* be turned in the direction of the arrow. Then, the engines being at rest, the drum and also the hunting screw are at rest. As a consequence of this, the rotation of *f* causes the sleeve *g* to screw down over *o*. The rod *m* moves to the left, the valve stem *n* and the valve *l* move up, and hence steam passes through *r* to the engines. At the same time the port *s* is placed in communication with the exhaust passage *t*. The engines now commence to turn, thus revolving the drum and also the hunting screw. Their direction of rotation is such that the hunting screw revolves in the same direction in which the shaft *f* was turned. Hence, the sleeve *g* moves upward again toward its original position, thus returning the valve to its mid-position and stopping the engines. The engines can only be kept in motion by turning the vertical shaft *f*, for as soon as its rotation is arrested the continued turning of the drum shuts the steam off the engines.

If the shaft *f* is turned in an opposite direction, the sleeve *g* will move up; the valve *l* will then be forced down and open the steam port *s*, at the same time placing the steam port *r* in communication with the exhaust passage *t*. When steam flows through *s* the engines will run in a reverse direction from that in which they run when steam flows through *r*. The opening of the port *s* starts the engines and rotates the drum, which in turn rotates the hunting screw in the same direction in which the vertical shaft was revolved, thus returning the sleeve *g* to its original position, which stops the engines.

A fourth design of a floating valve gear is that employed in the Cincinnati steam steering engine, made and patented by Crawley & Johnston. This gear is shown in Fig. 4 in perspective, chiefly in diagrammatic form. Referring to the figure, *F* and *G* are two single-acting steam rams; that is, steam is only admitted to one side of the piston—the after side in this case. The piston rods *T*, *T* are connected at the forward end to the tiller ropes and at the after end to chains that pass around the sheaves *R*, *R*, and are then fastened to the tiller *M*. The tiller ropes pass around the drum of the steering wheel. A horizontal shaft *E* is placed at a right angle to, and slightly above, the tiller ropes. It carries two crank-arms *A* and *B* that have rollers on their free ends; these rollers rest on the tiller ropes. Four sheaves *N* are placed close to the crank-arms. Steam is admitted to the cylinders by the pipes *I* and *J* leading to the steam chest *H*, which contains a rocking valve, by means of which steam may be admitted to, or exhausted from, either cylinder. The steam inlet for the valve chest is at *S*, and the exhaust outlet at *K*. The lever *L* of the rocking valve is connected to a crank *C* by a rod *D*.

Let the steering wheel be turned so as to tighten the port tiller rope. This raises the crank-arm *B*, depressing *A* at the same time. The valve lever *L* is pulled forward and the valve allows live steam to enter the pipe *J*, whence it passes to the port cylinder and drives the piston forward, thus pulling the tiller to port. But the starboard piston is pulled aft by the motion of the tiller, thus tightening up the starboard tiller rope, forcing the arm *A* upward, and closing the steam valve. The steam valve is so arranged that it allows steam to exhaust from one cylinder as soon as live steam is admitted to the other. If, now, the steering wheel is turned so as to put a strain on the starboard tiller rope, the valve lever *L* will be forced aft and steam will be admitted to the starboard cylinder. Should the rudder commence to creep, the strain put on either one of the tiller ropes will immediately cause steam to be admitted to one of the cylinders, thus returning the rudder to its position.

In this design, as in all the others here described, the pistons will move as long as the wheel or reverse lever moves, and in a direction depending on the direction of rotation of the wheel or reverse lever. As soon as the wheel or reverse lever is stopped, the onward motion of the tiller or piston shuts the steam off.

The list of floating valve gears is by no means exhausted with the four different kinds here given, which have been simply selected as representative designs.

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THE OCEAN DEPTHS

G. H. Dimpfel, Ph. D.

DIFFICULTIES OF MAKING SOUNDINGS—INSTRUMENTS USED—THE GREATEST KNOWN DEPTHS. CHARTS OF OCEAN BASINS AS AIDS OF NAVIGATION

FROM the earliest ages mankind has been inquisitive as to the ocean depths and the mysteries of life and beings they are supposed to contain. To the superstitious peoples of the old nations, the oceans appeared to be bottomless gulfs, haunted by sea dragons and other strange and miraculous beings. The value of some famous jewels belonging to the Doges of Venice was much enhanced by a legend attached to them that they had been brought by sorcery from the uttermost abyss of the sea. For centuries these confused ideas prevailed as to the great depths, and though we moderns do not share in them, yet we are as curious as were our forefathers concerning their exploration, in which the science known as *oceanography* has but recently achieved something, although it is comparatively little.

There is, however, a strong possibility that a considerable amount of positive information concerning oceanography and its allied sciences will be added to our meager stock of knowledge, since about two years ago, at a meeting of German naturalists in Leipsic, Germany, Professor Chun, of the Leipsic University, proposed that a deep-sea expedition be sent out for oceanographical, chemical, physical, and zoological investigations. The German Government gave $75,000 toward the expenses, and promised additional funds to cover final cost and publication of results. The Hamburg-American Steamship Company contributed the steamer Valdivia, of 2,600 tons burden, with crew and equipments, including a deck house for microscopic work, laboratories, and apparatus. The scientific staff is composed of eight specialists of reputation in oceanography, botany, zoology, chemistry, and bacteriology. The Valdivia sailed from Hamburg on August 1, 1898, and although the investigations have not yet been finished, and only preliminary reports have been furnished so far, the expectant public will certainly not be disappointed in the final results and achievements.

The reader will readily understand that the knowledge of the great depths of the ocean is only obtained with considerable difficulty. Deep-sea soundings are, above all other operations, liable to error, because of the prevalence of submarine currents of great force moving in various directions. These naturally interfere with the vertical descent of the sounding weight, and cause miscalculations as to the depth obtained. This probably accounts for some of the stories given in older nautical works, where depths of eleven, twelve, and even sixteen miles, are solemnly averred to have been sounded. In later days, however, great depths have unquestionably been properly ascertained by means of special instruments in the hands of competent and careful navigators and scientists. The instrument that is now usually used for the purpose of deep-sea soundings, and which has given general satisfaction as to accuracy, is known as Brook's line. It consists of a long iron rod, with a cup-like hollow at one end. The rod, when ready for use, is passed through a hole in a heavy iron ball, varying in weight from 70 to 170 pounds. This ball is fastened to a hinged fork at the top of the rod by means of a line passing around it, the ends of the line being drawn over two points of the hinged fork. The uppermost points of the fork carry the lowering line. While the weight of the apparatus is borne by the lowering line in passing through the water, the hinged fork is kept upright, and the ball is fast. As soon as the cup of the rod strikes the bottom, the hinges fall, and the ball slides off, leaving the rod to be pulled up with whatever may be in the cup in the shape of sand, shells, or other similar substances. The lowering line carries a number of knots at regular intervals, and from the increased or decreased rapidity with which these knots slide over the ship's rail, the striking of the point of the rod can be estimated with fair accuracy.

It was this instrument that gave the first proof that organism existed at great depths. From the plateau of the Atlantic Ocean it brought numerous perfect but very small shells; from the Indian Ocean, at a depth of about 3,500 yards, spicules of sponge. This was considered sufficient evidence that certain low forms of life can exist under immense pressure, in entire darkness and intense cold. That the pressure is indeed

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enormous can be readily conceived when it is remembered that a cubic foot of water weighs 62.5 pounds. Some of the earlier forms of measuring instruments were drawn back to the surface broken and rendered useless by the pressure to which they had been subjected. This is not to be marveled at, since the pressure is 14.7 pounds per square inch at the surface; at a depth of 30 feet, the pressure is doubled; at 60 feet, it is trebled; and so on in increasing ratio, until at a mile depth the pressure is about 3,000 pounds to the square inch. This means that a soft body, such as that of a man, for instance, should it reach such a depth, would be reduced to a shapeless pulp.

Yet the modern instruments have undoubtedly obtained accurate measurements of several miles depth. We know that the depth of the Atlantic Ocean is, approximately, 4,000 feet, and that of the Pacific Ocean about 13,200 feet. These are, of course, the averages. In some places there are immense depths, in others comparative shallows. The greatest efforts ever made for the exploration of these ocean basins and shallows, previous to the sailing of the Valdivia, were when the Challenger was sent out on its famous expedition by the British Government, in 1872; when Dr. Nansen explored the Asian Arctic Ocean and found depths of 10,000 feet and more for a long distance toward the pole; and when Lieutenant-Commander Moses, on August 10, 1896, discovered the enormous depth of 18,700 feet in Bering Sea, between Bering Island and Kamchatka. The officers and scientists of the Challenger expedition succeeded in obtaining, on March 24, 1873, what, until then, was the deepest sounding ever scientifically vouched for, viz., 23,250 feet, or nearly four and one-half miles. This depth was reached in the Atlantic Ocean, north of St. Thomas, and remained unprecedented until September, 1889, when soundings to a depth of 46,200 feet were made in the South Atlantic Ocean, midway between the island Tristan da Cunha and the mouth of the Rio de la Platà. This is the deepest sounding ever taken, but its authenticity is doubtful, although it was made with great care and in good faith.

The Mediterranean Sea also possesses some great depths. In March, 1891, during the deep-sea explorations carried on at the instance of the University of Vienna, Austria, a depth of 11,880 feet was measured between Molla and Cerigo. The greatest depth found by the Valdivia expedition, so far as is known, is 18,000 feet. The advantage gained by such researches have been very considerable. In searching the depths, minute forms of life have been discovered, and we know the causes of the ocean colors, which vary with atmospheric conditions; and our navigators, by observing them, are frequently enabled to prepare for approaching storms. We know now that the bottom of the ocean, as well as the land, is a succession of hills and valleys. Charts have been prepared of the ocean basins, and the shallower parts have been accurately mapped, with minute accounts added of their sands and beds, all of which have become aids to the mariner in determining his whereabouts by the use of a deep-sea lead. This instrument, always put in use when nearing a coast, is a long, leaden weight, resembling those used on our grandfathers' clocks, but much larger, varying in weight from 50 to 100 pounds. At the bottom of this lead is a hole about an inch deep by an inch and a half wide, known as the armhole. This is "armed" or filled with tallow. When the lead is cast overboard, it descends rapidly and strikes the sea bottom, the tallow picking up fragments strewn on the bottom. As some bottoms are rocky, and others muddy, and some composed of varicolored sands, shells, etc., an examination of these fragments will give the navigator an approximate estimate of his position. Perhaps the most profitable and extraordinary discovery ever made in the armhole of the lead, after heaving, was that of a guinea. This was brought up on the tallow from a depth of 90 fathoms, off the west coast of Africa, by a quartermaster, named Emanuel Davis, in the employ of the West African Steam Navigation Company. Such a thing was a chance in a thousand, and by no means proves that the bottom of the sea is, as some sanguine persons picture it, strewn with gold, costly pearls, and other untold wealth. There is gold, held in solution in appreciable quantities in the sea-water, but efforts to make its extraction a profitable business have been so far, and will be in the future, a failure. We have recently seen on the coast of Maine, where two smart Yankees started a "Gold Extraction Company," but only succeeded in extracting the gold from the pockets of the credulous stockholders.

It is said that another expedition for exploring the ocean depths is in contemplation, with the particular end in view of discovering the true nature of a substance resembling the white of an egg that is found

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in the deepest abysses. If this can be done, a great stride in knowledge will have undoubtedly been taken, for there are a number of biologists who consider it identical with the protoplasm that the late Professor Huxley, of England, termed "the physical basis of life," and have evolved a theory that "the germ of all life was matured in the ocean abysses in intense cold and darkness and under pressure so vast as to be almost inconceivable to the mind." These, of course, are but speculations; but apart from them there are secrets enough in the ocean depths to forever interest the world in their exploration. From them we are obtaining, year by year, fresh forms of animal life, new chemical elements and compounds, new theories of color, light, and motion. In short, the depths are vast storehouses, whence may always be obtained something new to add to the already large store of human knowledge, and, rifle them as we may, they will remain inexhaustible to the end of time.

GALVANOMETERS

James E. Boyd

THE ASTATIC COMBINATION—ARRANGEMENT OF COIL FOR ASTATIC PAIR—RELATION BETWEEN GALVANOMETER RESISTANCE AND OUTSIDE RESISTANCE

IN THE more sensitive galvanometers, the needles are generally suspended by a silk thread. Often a single fiber of silk is used for the purpose. The cheaper instruments are made as shown by the vertical section, Fig. 1. The magnet is hung near the middle of the wooden box by a thread fastened at the top to a pin in the center of the cover. The coil is oblong and is placed below the needle, the scale being between them.

Usually this kind of galvanometer is not as sensitive as the tangent galvanometer already described, because the magnetic force on the outside of a coil is less than inside. A much better plan is to have the needle in the center of the coil, as shown in Fig. 2. If the coil is small, the support must extend up through it. In Fig. 2 we have represented the needle and pointer supported on a small rod of aluminum passing up through a hole *a* in the coil. In high-class galvanometers the coil is wound in two spools, so that the aperture *a* comes between them, making it easy to take the magnets out.

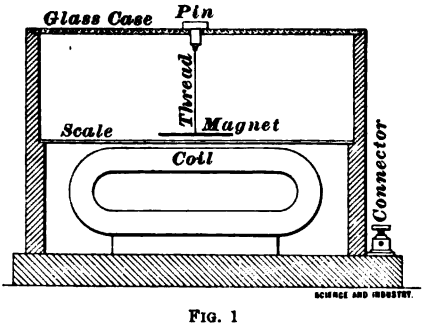

FIG. 1

For delicate galvanometers we make the needle short, which enables us to put it inside a coil of small inside diameter having a great number of turns. There is a limit to this, however, and other means must be adopted to make the galvanometer more sensitive; for example, the astatic-needle combination is one of these. Two needles are fastened to the same support with their poles in opposite directions, as shown in Fig. 3.

When such a combination is hung up and deflected a little from the magnetic meridian, one magnet tends to turn it on around and the other to pull it back to its original position. If the two magnets are exactly equal, the two forces will balance, and it will stand wherever it is placed. Here we have a true astatic combination. If, however, one magnet is a little stronger than the other, the magnets will rotate in the direction of the stronger force. In a uniform magnetic field, a combination that is nearly astatic is equivalent to a very weak needle; there would be no advantage in the use of such a combination if the two needles were placed close together. In use, such needles are fixed an inch or more apart, so that one needle may be put inside a galvanometer coil and the other above or below it; the second magnet of such a combination is represented by the dotted figure *S N*, Fig. 2. Suppose the current in the coil passes around it in a clockwise direction, so that the lines pass

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through the coil from front to back. The pole *N* tends to turn farther around so as to move the front of the pointer toward the left. At the same time the lines of force above the coil run from the back toward the front, tending to carry the

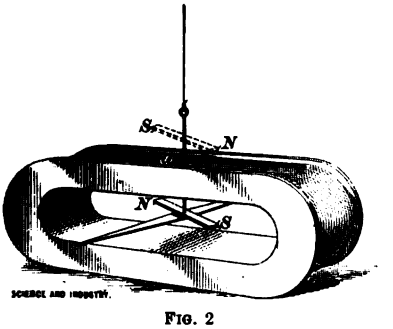

FIG. 2

north pole of the upper needle forward. The effect of this, then, is to rotate the front of the pointer toward the left; at the same time the earth's magnetism, which we will suppose to be parallel to the coil from right to left, tends to twist the lower needle in one direction and the upper needle in the other. If the lower needle is the stronger, we have a very weak force tending to make the needles parallel to the coil. The force that the current in the coils exerts on the needles varies with the sum of their strength, while that due to the earth's field varies with their difference. If the needles are strong and nearly equal, a small current in the coil will produce a large deflection, provided, of course, that a fine fiber is used as a support, so that no appreciable force is required to twist it. It is easy to make a galvanometer of this kind. Make the magnets out of pieces of sewing needles about an inch in length. To magnetize a needle, hold it down on a block of wood, and, placing the north pole of a permanent magnet on the center, draw it off at one end. The point where the pole of the magnet leaves the needle will be a south pole. Then, turning the needle end for end, place the south pole of the permanent magnet gently on the middle and draw it off at the end; this gives a north magnetic pole at this end. This operation may be repeated several times, changing the ends of both magnet and needle each time. Stroking the second needle in the same way will probably make it nearly equal to the first. The two needles may be mounted with their poles in opposite directions on a short rod of brass, aluminum, or wood.

The coil may be wound in the form shown in Fig. 2. It is convenient to use a slot long enough for the magnet to pass through, instead of the round hole *a*. The pointer may be made of an aluminum wire or a broom straw, and for convenience should be placed above the coil and not inside of it, as shown. As a suspension, split a few fibers from a silk thread—untwisted silk is the best.

The coil and support for the thread, of course, must be mounted on a wooden base, so that the suspended needle shall swing near the center of the coil. A glass cover, or a wooden box with a mica or glass window, may be put over the instrument to prevent disturbance due to the air. Such a galvanometer is capable of doing very good work. It will show the current due to heating a single junction of two dissimilar metals, or the current induced in a coil of a few turns, by thrusting a magnet into it.

The question naturally arises whether our galvanometer coil should be wound with a few turns of coarse wire or a great many turns of fine wire—whether it should be a high- or low-resistance coil. In purchasing galvanometers or in using them where there are several instruments at our command, we often meet the same problem. In general, we should use a high-resistance instrument on a high-resistance circuit, and a low-resistance instrument on a low-resistance circuit, if sensitiveness is desired. Of course, there may be other considerations, such as the danger of short-circuiting a cell, which may require the use of a less sensitive arrangement.

Suppose we desire to connect our galvanometer to a cell having a resistance of 1 ohm, and we use a coil having $\frac{1}{10}$ ohm per turn and 20 turns; the total resistance of the circuit is 3 ohms, and, supposing the E. M. F. to be .0015 volt, the current is .0005 ampere. Now let us put on 20 more turns having the same resistance as the first; the resistance is now 5 ohms and the current .0003 ampere. In the first case we have .0005 ampere through 20 turns, and in the second we have .0003 ampere through 40 turns; if the coils are exactly alike we have a force at the center in the second case 1.2 times as great as that in the first case. In winding a coil, however, we soon fill up the space nearest the needle,

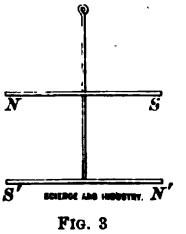

FIG. 3

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so that when more turns are added they must be placed farther from the needle when their force is less, and must generally be of greater diameter and have greater resistance than the inner turns. In winding coils, then, we soon reach a point where the increase of resistance balances the gain secured by putting on more turns.

In the simple thermopile made by twisting together one end of a pair of wires—iron and German silver, for instance—and joining the free ends to a galvanometer to measure the current produced when the junction is heated, we have a case where the galvanometer should be one of low resistance. Here the E. M. F. is small and constant, while the resistance outside the instrument is that of a few feet of wire. Again, a low-resistance galvanometer is used to measure the current generated by cutting lines of force by a few turns of wire. A comparatively low-resistance galvanometer is most sensitive when using a bridge of low-resistance arms, and when finding the drop of potential in a low-resistance wire. Low-resistance galvanometers are usually made of sizes from No. 18 to No. 24, and have from 50 to 500 turns in their coils.

When the outside resistance is large, little is gained by diminishing the resistance of the galvanometer. If there are already 10,000 ohms in a circuit, the addition of 1,000 ohms in the galvanometer will diminish the current only one-tenth, and, if at the same time the number of turns is doubled, the sensitiveness is very much increased. High-resistance galvanometers are used for measuring insulation resistance and with bridges of high-resistance arms. In discharging a condenser, the same quantity of electricity flows out, no matter what the resistance, though it takes a longer time when the external resistance is high. The galvanometer used to measure this electricity may be of very great resistance, and must have a large number of turns. High-resistance galvanometers are wound with wire of about No. 40 gauge, and many thousand turns are put in a single instrument.

QUESTIONS FOR STEAM ENGINEERS

(*Continued from the January, 1900, Number*)

Chas. J. Mason

THE STEAM BOILER—HOW INTERNAL PRESSURE ACTS—THE USE OF FORMULAS—THE STRENGTH OF RIVETED JOINTS—BOILER PLATE

A BOILER is a vessel in which steam is generated. Boilers may be divided into three classes: stationary, locomotive, and marine. Portable boilers, such as belong to fire-engines, street rollers, and hoisting engines, are usually classed as stationary boilers, and come under the supervision of the civic authorities in such places where laws exist in regard to the inspection of steam boilers. Of the three classes of boilers just mentioned, there are many kinds of makes, or subclasses, so to speak. This article will deal principally with the stationary class, and it will not be attempted to give descriptions in detail of the various kinds, but rather to explain principles and rules applicable to all.

When the construction of steam boilers was in its infancy the pressures carried were not more than 3 or 4 pounds per square inch. Not much attention was then given to the form in which the boilers were to be made—so far as the suitability to resist internal pressures was concerned. When higher pressures were used, attention to this important point became necessary. Today, from 100 to 200 pounds per square inch is not uncommon, and so the strongest form possible must be employed in the construction of boilers. The sphere is the strongest form to resist internal pressure, but for many reasons it cannot be adopted. Next to the sphere is the cylindrical form, which is now universally used.

Why is the sphere the strongest form to resist internal pressure?

Internal pressure acts radially from the center on every part of the internal surface of the vessel. As an illustration of the form in which pressure tends to shape a vessel, the toy rubber balloon with which our children play will serve our purpose. At first, when subjected to the external pressure of the air, it is a shapeless body, but when internal pressure is introduced, it swells out and assumes the form of a perfect sphere. It is,

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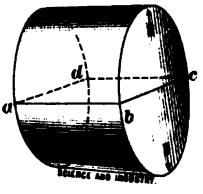
therefore, a logical conclusion that as internal pressure would surely tend to make a vessel conform to a sphere, such a form must be the strongest to resist the pressure. It can readily be shown mathematically that for a given thickness and strength of material a spherical vessel will have twice the strength of a cylindrical vessel.

In the cylindrical form of boiler, all flat surfaces must be stayed, or braced, owing to the tendency of the boiler to assume a circular form while under pressure. It will be noticed that stays are not used for the circular part, because the internal pressure tends to make all parts circular, or as we commonly say, "the circle stays itself."

Boilers are made of steel or iron plates riveted together at the joints in such a way as to be both strong and tight. Now, these joints are very important factors in calculating the pressure a boiler can carry, and it may be said that the influence of these joints is not very well understood by many of those that are daily employed around a steam boiler. It is known to many, of course, that the longitudinal joints are double- and sometimes treble-riveted, while the circumferential joints, or seams, as they are also termed, are only single-riveted. Nearly every one knows, or can infer, from the fact that the longitudinal seams are double-riveted, that they are subject to a greater stress than the circumferential seams; but the main question is:



Why is there more stress on the longitudinal than on the circumferential seams?

The answer to this question is not as easy (to those that have not already studied and thought out this problem) as it at first appears to be, and, until it has been carefully studied and understood, will cause confusion of ideas that will surely entangle those that have not taken the trouble to look into it. The mere reading and looking at the following explanation and formulas will not avail much, and if the reader really desires to be informed on the subject, he must think hard—take pains to gain his desires. There are many things in engineering that, while a clear and full explanation of them may be given, require individual effort in order to be understood and retained. It is of little use to commit a given formula or rule to memory, for, unless used frequently, it would soon be forgotten, especially when there are so many to remember. If the formula is studied in the true sense, it will seldom be forgotten, for the mind is not burdened with trying to remember what has been mentally digested. By the phrase "in the true sense," is meant the searching out of the reason the different factors in a formula are placed as they are. Sometimes it will be extremely difficult to understand a problem, and much time may be spent on it without results. Now and then a gleam of light may burst upon your mental eye, and you have almost mastered your difficulty, but not quite. This at first may seem discouraging, but in reality it is one of the best experiences that could happen you; your mind is undergoing a training—it is being disciplined. Instead of feeling discouraged, such experience should encourage you to further and greater effort. Perhaps, at such a time, it would be well to discontinue the subject for a time, "sidetrack it," so to speak, and continue with the subjects next in order. You will be much surprised, when you again resume the difficult problem, at how much clearer it appears to you now. Problems studied under such circumstances are not easily forgotten; and, what is more, no special effort will be required to remember them. Knowledge acquired under such difficulties becomes part of ourselves, stowed away in the mind's great storeroom, always ready to be brought out when required.

To return, let us see what is the meaning of the word *stress*, as used in the question with which we are dealing. A force that tends to produce a change in any body is called a *stress*. Do not confound it with that other term *strain*, for there is a difference—a strain results from a stress. It has been stated that the stress on the longitudinal seams of a boiler is greater than on the circumferential seams. Now, let us look into this and see why it is so. A simple way of explaining this is by the use of a diagram, which represents a cylinder subject to internal pressure, just as in the case with a steam boiler.

Let

P = pressure per sq. in. in the cylinder;
D = diameter of the cylinder in inches;
T = thickness of the plate;
L = length of the cylinder in inches.

The internal pressure P acts radially on every part of the internal surface of the cylinder, and tends to separate the cylinder into two parts along any plane passing through the axis of the cylinder, as $a\,b\,c\,d$. This requires a little thinking. The plane

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$a\,b\,c\,d$ is an area represented by the diameter and length of the cylinder when multiplied together. Now, the pressure, or force, that tends to separate the cylinder has this area as a backing from which to act (we speak thus for the sake of simplicity), and thus it can be seen how the product of $P \times D \times L$ is the resultant force tending to separate the cylinder into two parts along the lines $a\,b$ and $c\,d$. On this fact are based all the calculations concerning the strength of the shell of the steam boiler. If this fact is clearly understood, half the trouble in learning the different rules will be removed.

The area of the material in our cylinder to resist this tendency to burst along lines $a\,b$ and $c\,d$ (in other words, the two sides of the cylinder) is equal to $(a\,b + c\,d)\,T$, or $2\,L \times T$, which means twice the length, or the length of the two sides, multiplied by the thickness of the plate of which the cylinder is made. Therefore, the stress per square inch on the plate may be shown thus:

$$\text{Stress} = \frac{P\,d\,L}{2\,T\,L} = \frac{P\,d}{2\,T}$$

As the factor L (the length of the cylinder) is common to both numerator and denominator, they equalize each other and can therefore be stricken from both. This formula translated into words is: The pressure per square inch in the cylinder, multiplied by the diameter of the cylinder in inches, divided by twice the thickness of the plate in inches, will give the stress per square inch on the plate.

By a careful study of the above it will be seen that, by changing the value of the letters in the formula, the result will also be changed. For example, if we increase the values of P and D, the stress will thereby be increased; if we increase the value of T, the stress in this case is decreased. The facts first cited govern the size and thickness that a certain boiler must be in order to withstand a given pressure.

We have been dealing with the stress that tends to separate the cylinder (shown in our illustration) along the sides. So far nothing has been said about the pressure, or stress, on the ends, or heads—that stress which tends to tear the cylinder into two parts in a plane perpendicular to the axis, or, in short, which tends to blow the end off.

First we find the area of the end by the formula, $d^2 \times .7854 = \text{area}$. This means that the diameter squared (multiplied by itself), multiplied by the constant .7854, equals the area; all being expressed in inches. The total pressure on this area, or end $= (d^2 \times .7854)\,P$; or, the area as found above, multiplied by the pressure per square inch, equals the total pressure tending to blow the end off. Now, the area of the material to resist this tendency (not taking into account the deductions that would have to be made for rivet holes in the case of a boiler) equals the circumference of the cylinder multiplied by the thickness of the plate; thus, area $= d \times 3.1416 \times T$. This means that the diameter multiplied by the constant 3.1416 (the circumference), multiplied by the thickness of the plate, equals the area of the material to resist the end being blown off. Therefore, the stress per square inch on the plate will be:

$$\text{Stress} = \frac{d^2 \times .7854 \times P}{d \times 3.1416 \times T} = \frac{P\,d}{4\,T}$$

This means that the pressure per square inch, multiplied by the diameter of the cylinder in inches, divided by four times the thickness of the plate, equals the stress per square inch on the plate.

By comparing the result just shown with that in the other case, it will be seen that the stress is only half as great in the latter case. Theoretically, the plate is twice as likely to give out in the direction of the length of the cylinder as it is circumferentially. For this reason the longitudinal joints of a boiler are made stronger than the circumferential by an extra row of rivets.

Perhaps the formula just stated will appear confusing to some readers, and there is no doubt that it is so, unless it is carefully studied. At first it seems difficult to see how $d^2 \times .7854 \times P$ can be reduced to simply $P\,d$; and likewise in the second line, how the expression $d \times 3.1416 \times T$ can be expressed as $4\,T$. Of course, if we should take either expression singly, we could not make such reduction; the terms must be treated according to the relation existing between them. If the reader will substitute numbers for the letters used in the expressions, and then figure out each correctly, he will find that the same result will be reached. Try it for yourself; by doing so a desire to go further may be awakened, which cannot but be of great benefit.

As has been said before, having once mastered these two problems, concerning the longitudinal and circumferential stresses, all the others concerning internal pressure will be quite easy.

In the foregoing examples the cylinder in question was considered as being formed of one continuous piece of metal, without joint or seam, in order to better explain the

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principles involved. In steam boilers in actual use such conditions do not exist, for it is not practicable to make them thus, but they are made of several sheets of metal, and, consequently, there must be joints and seams. These joints are not as strong as the original sheets, owing to the holes for the rivets that have been drilled or punched in them. A certain portion of the metal has thus been removed, and therefore the sheets have been weakened to a certain degree.

The strength of the joints in a boiler is expressed as a certain percentage of the strength of the solid plate. This percentage depends on several things that must be taken into consideration when making the calculation, and, therefore, no definite figure representing the percentage can be given. True, there are two figures in general use, that are assumed to be averages of the different percentages. These figures are 70 and 56 for double- and single-riveted seams, respectively, and are found in a great many engineering handbooks. These figures are sufficiently close for general purposes, and save much time when making calculations pertaining to the strength of a steam boiler. But when dealing with joints it cannot be taken for granted that these figures are correct. The reader will understand that the longitudinal seams of the steam boiler are usually taken as 70 per cent. of the strength of the solid plate when such seams are double-riveted, and 56 per cent. when single-riveted.

On what does the strength of seams depend?

The real strength depends on the proper proportions being maintained between the diameter and pitch of the rivets, and on the thickness of the plates. The following is the formula for finding the strength of joints:

$$\frac{(P - R) \times 100}{P} = S_p,$$

in which P = pitch;
R = diameter of rivets;
S_p = percentage of strength of plate at the joint, as compared with the solid plate.

This is all right so far as the plate is concerned, but what about the strength of the rivets? Let us see:

$$\frac{(A \times R) \times 100}{P \times T} = S_r,$$

in which A = area of rivets;
R = number of rows of rivets;
P = pitch;
T = thickness of plate;
S_r = percentage of strength of rivets, as compared with the solid plate.

This last formula is to be used for lap joints and those having single butt straps. Should double butt straps—joints—be used (as in marine boilers) multiply the percentage found by 1.5, for in such cases the rivets are exposed to double shear.

There is food for thought in these formulas, and we cannot emphasize too strongly the importance of getting into them, as it were—to pick them to pieces, to analyze the different parts—not pretending to commit to memory the mere positions of the factors, but, instead, searching out the reasons that determine their relative positions.

In all these formulas that we have been considering, it would be well for the student or reader to supply numerical values in place of the letters and words, and work them out for himself. Change these values in certain factors and note the results obtained; experiment with them in every way you can think of; by so doing you will unconsciously learn that which you may not have actually set out to learn.

It may not be out of place here to make a few remarks about formulas in general. Many engineers and mechanics have a dread of them, so much so that many articles in mechanical journals go unread. Some persons have an idea that one must have a knowledge of algebra in order to be able to work out a formula, and, not having the supposed necessary knowledge, do not bother with it at all. The formulas used in textbooks and journals that reach the steam engineer are simply arithmetical questions or statements expressed in an algebraic form for convenience. A knowledge of algebra—excepting that relative to the use of the signs in formulas, which is very simple—is not required to work out the formulas with which we have to deal. In fact, they are so simple and easily understood that they are now universally used by almost every one. In short, a formula is a method of stating a question in a clear, concise, and condensed form, instead of using a great number of words. Any person understanding simple arithmetic should have no difficulty in solving a problem that is expressed in a simple formula.

What are the essential qualities that should be possessed by plates used in the construction of steam boilers?

There are two qualities that all boiler plates should possess. The first is tensile strength sufficient to stand the stress put on it by the pressure of steam; and the second is ductility, to prevent cracking by unequal

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contraction and expansion, and by repeated heating and cooling. The latter quality is just as essential as the former.

What is the meaning of the term "tensile strength"?

The tensile strength of any material is the resistance it offers to being pulled apart. When we speak of the plates in a boiler having a tensile strength of 50,000 pounds per square inch, it is meant that if a bar of the same metal, 1 inch square, is subjected to a stress of 50,000 pounds, it will break. This is called the *breaking stress* and also the *ultimate tensile strength*. From this it can be seen that the resistance of a plate is proportional to the area of its cross-section. When it is required to find the breaking stress of any piece of material we find the area at the minimum cross-section, and multiply it by the strength per square inch. The tensile strength of wrought iron may be taken as 50,000 pounds per square inch of section; that of steel, 70,000 pounds per square inch of section. These figures may not always be found correct; an actual test only can determine just what the tensile strength is. The term *safe tensile strength* refers to the load per square inch that can be borne in safety by a piece of material. In boilers, it is usually taken at from $\frac{1}{6}$ to $\frac{1}{5}$ the ultimate tensile strength of the material.

What is the meaning of the term "ductile"?

Ductile, as applied to the plates of a boiler, means that the plates may be subjected to a stress sufficient to stretch them within reasonable limits without breaking. The *elastic limit* of the metal in question determines how far this stretch may be carried before a permanent set becomes visible. A metal that has no elasticity, and is not ductile, is not safe to use in the construction of a steam boiler.

THE FACTORY CHIMNEY

"Constructor"

SOME FEATURES IN CONSTRUCTION THAT SHOULD BE OBSERVED

THE tall factory chimney of masonry is rapidly being superseded by the smoke-belching, gas-distributing funnel of the induced-draft system. The fan, though hard at work in the economizer room in its endeavors to lift the coal from the grates and propitiate the wrath of the engineer by a good showing on the draft gauge, refuses to assist the products of combustion farther than the base of the stack. That poor 40-foot No. 10 iron affair is either unable or lacks sufficient ambition to send the fumes and smoke clear of the angle-iron ring that adorns its top, much to the discomfort and annoyance of the neighborhood.

The economizer is excellent in its way, but the induced-draft system, with its short stack, smoke nuisance, and big repair bill for the fan engines, which are usually overloaded, cannot be compared with its old-fashioned and stately competitor—the brick or stone chimney, sending the smoke far above the housetops and chimney caps of the town.

It is not, however, the purpose of this article to compare the several systems of creating draft; for, as the bookkeeper of a boiler shop said, in replying to the question of a prospective customer as to whether it was advisable to use 2½-inch or 4-inch tubes in a certain boiler, "that's merely a matter of taste." What it is desired to set forth, is a few points that may be of use to those that still favor the brick or stone chimney; and, as the brick chimney is the most usual, the remarks are intended to be relevant thereto.

The location of the brick stack or chimney is naturally subservient to the arrangement of the boiler house, but should be, wherever possible, isolated from it; that is, the stack and the walls of the boiler house should not join; neither should the foundation footings be in conjunction, unless, of course, the soil is unyielding, and settlement unlikely. If it is imperative that the chimney shall join the wall of the boiler house, in order that the flue can be run to the best advantage, or for other reasons, a straight joint should be provided, which will allow unequal settlement between the stack and the wall without danger of destroying the continuity of the latter.

The foundations should be carefully proportioned, so that the safe bearing value of the soil is not exceeded, and attention should be paid to the lay of the land, and, if necessary, drainage should be provided in order to carry off spring and surface water. Where clay or yielding soil is encountered, it is usual to provide concrete footings, which in extreme cases are constructed on the grillage

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system. The foundations and footing courses of brick and stone chimneys are generally made much heavier than for walls of buildings, because the increased weight is required to provide stability against wind pressure. It is not unusual for a chimney 200 feet in height and 20 feet on a side at the base, erected upon clay or other unstable soil, to have the foundation of concrete 10 to 12 feet in depth, and even more. This concrete foundation or footing should be stepped inside and outside not more than 2 of vertical to 1 of horizontal run. The inside of such a foundation may be filled with brick or concrete, to add weight, and faced with firebrick to form the floor of the stack.

Brick chimneys may be either round, square, octagonal, or star-shaped in cross-section. Round and octagonal chimneys offer less resistance to the wind than square ones, and are more expensive to construct, specially molded brick often being required for round chimneys, particularly for the inside lining. Some of the tallest and best constructed brick chimneys are star-shaped on the outside perimeter, being usually eight-pointed, which is the outline formed by the overlapping of two squares, the diagonals of the one being coincident with the diameters of the other. Chimneys built in this manner are well adapted to resist wind pressure, and make a fine appearance where the flutings or star points die away into a neatly corbeled bell cap. The width of the chimney at the base, if square, should be about one-tenth of its height, and it is good practice to use a batter of about 2½ inches to every 10 feet of height. However, in the design of all chimneys, the overturning tendency due to a horizontal wind pressure of 56 pounds per square foot should be calculated, and the chimney designed to resist such a tendency.

The center of action of the wind is taken at the center of gravity of the stack surface. This point can readily be determined by laying out an elevation of the stack to scale on cardboard, cutting it out and balancing it. The transverse axis thus found will pass through the center of gravity of the surface and the point at which the wind pressure on the stack is considered as being concentrated. The center of gravity may be also determined by the analytical method usually employed. The amount of the concentrated wind pressure on square chimneys is equal to the exposed surface in square feet multiplied by 56, the unit pressure in pounds. The pressure on a round stack of the same diameter is only half as much.

The leverage with which the wind acts is the distance from the base to the center of effort of the wind, and the product of this distance by the force of the wind is the overturning moment that must be resisted.

The resistance to overturning is the result of several factors. One is the weight acting through a lever arm equal to the distance from the center of gravity of the base to the leeward edge or side of the stack around which the stack tends to tilt or turn. The second factor of resistance is the adhesive strength of the brick and mortar, which acts throughout the cross-section of the stack, tending to prevent rupture in the brickwork and the overturning of the portion above the point of rupture. If the modulus of rupture of brickwork were a determinate factor, the section of the stack could be considered as a beam section, and its resisting moment determined. If it is necessary to consider the adhesive strength of the brickwork at all, the safest practice is to assume a low allowable unit adhesive value, say from 7 to 10 pounds per square inch for lime mortar, and consider one-half of the stack section as being effective. The adhesion of this half section acts with a leverage or moment about the leeward side or edge of the stack. The leverage being the distance from the center of gravity of the half section to the leeward edge, the moment of resistance is the product of this distance by the area of the half section and the unit adhesive value of the brick and mortar.

In determining the stability of brick stacks and their power to resist the overturning force of high winds, the proportionate relation between the weight, height, breadth of base, and exposed area of the chimney may be expressed by the following equation:

$$P \times h \times d \times \frac{\frac{h}{2}}{\frac{b}{2}} = W.$$

Simplified, this equation gives

$$W = P\frac{h^2 d}{b},$$

in which

W = weight of the stack, in pounds;
h = height, in feet;
d = mean width of the stack, in feet;
b = breadth of base, in feet;
P = wind pressure, in pounds per square foot of area.

The value of P varies with the cross-section of the chimney, and equals 56 for a square, 35 for an octagon, and 28 for a round chimney.

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The above equation is simply a deduction or formulation of the principles as previously given, with the exception that the center of wind effort was taken at one-half the height of the stack, and the area as the product of the mean width of the stack by its height. These assumptions are more or less erroneous, depending on the shape of the stack. The equation is, however, accurate enough for all practical purposes.

In applying the equation, consider, for example, a square chimney 200 feet high and having an average breadth of 17 feet and a width of base equal to 20 feet. The weight W of the stack should equal $P \frac{h^2 d}{b}$, or $56 \times \frac{200 \times 200 \times 17}{20}$, which gives 1,904,000 pounds, and would require a stack whose walls average 17 inches in thickness.

The thickness of the brickwork in the chimney will also depend on its height, and the crushing strength of the material must be considered as well as the resistance against the overturning tendency of the wind; the allowable bearing value of brickwork in lime mortar being taken at 100 pounds per square inch. The thickness of the brickwork at the top of chimneys 100 feet in height and over should not be less than 13 inches for a distance of 30 feet from the top, as this portion of the chimney suffers most from exposure and the destructive action of the gases. Adopting this thickness at the top, it is good practice to increase the thickness of the wall 4½ inches for every 20 feet measured downward.

Brick chimneys subjected to great heat, such as are employed in incinerating plants or similar works, should be lined with firebrick nearly their full height. Where the chimney heat is comparatively low, as is the case with the ordinary boiler plant, the firebrick lining need extend only up the stack from 25 to 50 feet, depending on the height of the stack. The air space that should exist between the lining and the stack wall should be from 1½ to 3 inches, and should always be closed at the top with a sealing course, to prevent soot from falling into the air space. If, however, the chimney is tapered and the lining course straight, it will run to a close at the top, but in no case should the firebrick lining be attached to the brickwork of the stack, as it is imperative that they shall be entirely free of each other, in order that they can expand separately.

Care must be exercised in building the openings at the base of the stack for the flues and clean-outs. They must be well arched, and in good work should be provided with an inverted arch that will transmit the pressure to the foundations. The sides, bottom, and top of all such openings should be lined with firebrick and the inside edges of the flue rounded. The clean-outs should be provided with suitable cast-iron doors and frames, secured to the brickwork with binder bolts. The doors of the clean-outs may be hinged or otherwise arranged, so that they may be conveniently opened and securely closed. The size, shape, and number of the clean-out doors is optional, but they should in any case be large enough to admit a man.

The top of the chimney should be protected by a cap of either terra cotta, cast iron, or stone, and in large stacks must necessarily be made in sections. If a cast-iron cap is used, the several sections are provided with flanges so located that they can be readily bolted together when set in place on the top of the stack. One of the principal objections to cast iron for this purpose is that the rust unites with the moisture and runs down the stack, discoloring the brickwork. Such an objection, however, is not serious, and as the top of the stack is usually well smoked anyway, cast-iron caps are much favored.

If stone or terra-cotta caps are used, provision must be made to secure the sections in place and the vertical joints so arranged as to exclude moisture, thus preventing the danger of displacement by freezing.

Capstones should be carefully selected; blue sandstone will probably be the most durable. Limestones should not be used, as they are liable to be affected by the sulphuric acid generated by the gases at the chimney top. Granite is liable to split with heat, especially when cooled suddenly, as with water, and could only be used with success when the heat is low.

Whether the cap is built of cast iron, terra cotta, or stone, it should be provided with an ample overhang, and be so designed as to shed and drip the water clear of the top of the stack.

The protection of tall chimneys with lightning rods cannot be too strongly advised. It has been conclusively determined that structures of greater height than the surroundings are especially susceptible to damage by lightning, and that the destructive effect of the stroke is greatly ameliorated by the use of well-grounded and properly constructed rods.

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THE DEVELOPMENT OF THE MECHANICS OF MATERIALS

Benj. F. La Rue

A HISTORICAL RESUMÉ OF THE EARLIER STEPS IN THE DEVELOPMENT OF THE THEORIES RELATING TO THE STRENGTH OF MATERIALS

MECHANICS of materials is the name commonly given to the theories relating to the capabilities of material bodies of different forms to resist, under various conditions, the effect of externally applied forces or loads. This subject is now, in most of its aspects, quite thoroughly understood, and the laws relating to it are so well established as to enable us to construct large and complicated structures and machines with absolute safety and the highest possible degree of economy. The development of this very important science is, nevertheless, recent, having been wholly within the last two centuries.

Nearly, if not all, of the earlier endeavors to solve the problem of the strength of materials were directed toward the investigation of the strength of solid beams, which was finally accomplished by Navier, after several attempts in which he went quite astray. About the year 1824 he succeeded in putting the matter on a solid mathematical basis, and established for all time the correct approximate theory of flexural resistance. It will be of interest to follow the various steps in the development of the science leading up to the final successful achievement of Navier.

So far as is known, Galileo was the first to attempt to propound a theory for the strength of material bodies of any form. His famous Dialogues (Leiden, 1638) contain a theory for the strength of beams which, though proved erroneous by the more recent development of greater knowledge, is nevertheless very ingenious. His theory was based on the erroneous assumption of absolute rigidity of the material; that is, he assumed the material to be perfectly rigid and inelastic, whereas all materials are now believed to be more or less elastic. Assuming a condition of perfect rigidity for the material, he concluded that a load upon the outer end of a beam projecting from a wall, into which the opposite end was firmly imbedded, tended to rotate the beam about its base as a fulcrum, subjecting the fibers to a uniform tension. Computed according to this theory, a beam of rectangular cross-section would have just three times the strength given by the theory of the flexure now generally accepted. Galileo's theory, though erroneous, was an important step, and is supposed to have been the first step, in the development of the now well-established laws relating to the mechanics of beams.

Forty years later, or in 1678, Robert Hooke first published his now famous law of the relation between stress and deformation, which, he stated, had been discovered by him eighteen years previously, but had been kept secret in order to procure patents on certain applications of the principle to springs for watches, clocks, etc. Three years previously he had performed experiments in the presence of the king of England, illustrating the law. He had also previously ventured to publish it in an anagram at the end of another book. It was given in the form

"*ceiiinosssttuu*,"

which by some system of interpretation was made to read "*ut tensio sic vis*," a Latin phrase meaning, "*as the extension so the force*"; that is to say, in a spring acted upon by an elongating force the elongation is proportional to the force, or, stated in a more general sense, the deformation in a body acted upon by an external force or load is proportional to the force causing it. Hooke considered this law applicable to all "springy" bodies, naming as among these nearly all ordinary and familiar solids.

The announcement of this important law thus embraced two distinct principles that have stood the test of time and are now very generally recognized and accepted:

First, the stress is proportional to the deformation. This law is now universally accepted as true of any material within the limit of its elastic resistance, although it is also known that there is for every material a limit, more or less well defined, beyond which the ratio between stress and deformation does not remain constant, the deformation increasing more rapidly than the stress, until rupture occurs.

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Second, among the materials to which Hooke considered his law applicable, that is, which he considered as "springy" bodies, he included nearly all ordinary solids—possibly *all* of the ordinary solids then known whose characteristic properties were familiar to him and to which it had occurred to him that any application of the law would be desirable or practicable. It is now believed that all solids are elastic, although it is well known that the degree of elasticity varies greatly in different solids.

It is thus evident that the discovery and announcement of this law embraced two distinct principles, which, though imperfectly stated, may be called the pioneers of what is now accepted as correct theory. To do this was truly a great achievement. The law, which has become justly famous, is still known as *Hooke's law*.

The next step in the development of the mechanics of beams was purely experimental. In 1680, Mariotte showed by means of experiments that the fibers on one side of a loaded beam were extended and those on the other side compressed, or shortened. He concluded that between the extended and the compressed fibers there existed a neutral surface in which the fibers were neither extended nor compressed, and *assumed* that this neutral surface passed through the center of gravity of the section. The assumption has since been shown to be correct when the stress does not exceed the limit of the elastic resistance of the material.

Had Mariotte *proved* this, it would, indeed, have been a very important step in the development of the mechanics of materials. But even if Mariotte did not prove it, he interpreted his experiments correctly; and although he did not demonstrate completely his theory relating to the flexure of beams, yet in deference to its statement of what is now acknowledged to be true principle, it is sometimes called *Mariotte's law*.*

Some progress was made in 1702, when Varignon attempted to harmonize the theories of Galileo and Mariotte. He accepted the latter's theory of the extension of the fibers, but, by neglecting their compression, located the neutral surface on the compressive side of the beam, as Galileo had done, and assumed the tensile stress to vary uniformly from this to the opposite side of the beam. According to this theory, the strength of a solid rectangular beam would be just twice its strength as given by the commonly accepted theory of flexure. Though this attempt was quite erroneous as a whole, it contained an element of progress in the idea of the stress increasing uniformly from zero at the neutral surface to a maximum intensity in the fibers most remote from that surface.

Between 1694 and 1705, James Bernouilli effected some advance in the theory of the mechanics of materials by applying Mariotte's law to obtaining the deflection of beams, but committed the great error of assuming the position of the neutral surface to be a matter of indifference. He also denied the truth of Hooke's law, which seems remarkable, as he was the first to construct what are known as stress-strain curves, showing graphically the relation between stress and deformation. His ideas were progressive, but they were also somewhat erroneous.

That the laws of mechanics show the necessity of a condition of equilibrium between the tensile and compressive stresses seems to have been first perceived by a French academician by the name of Parent, about the year 1713; but this discovery, though of greatest importance, appears to have passed unnoticed at the time. Sixty years afterward, or in 1773, the principle was reannounced by Coulomb, in a memoir to the French Academy. The discovery of the principle was probably the result of original work on the part of Coulomb, as he had probably never seen Parent's work. But even after the second publication of this principle, which is one of the most important truths relating to the mechanics of bodies subjected to transverse loading, there existed much misconception regarding it, and several well-known writers of the subsequent time, in endeavoring to explain the strength of beams, failed to discern the true mathematical necessities of the problem, and as a consequence gave forth theories that were quite erroneous.

Navier, whose labors in this field extend from 1820 to 1833, appears to have been the first to comprehend clearly the principles relating to the strength and deflection of beams. His efforts were for a while somewhat erroneous, however, and the first and second editions of his published work contain errors of considerable importance. But in 1824 he developed a correct and complete mathematical theory for the strength of beams, based on a clear and accurate discernment of the conditions of the problem as

*This should not be confused with the well-known law of the relation between the volume and pressure of gases propounded by the same great physicist, which is commonly known as *Mariotte's law*.

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now understood. He also perfected the theory of the deflection of beams and developed the equations of the elastic curve. Navier has thus the distinguished honor of having established on a solid foundation the modern mathematical theory of the elasticity and flexural resistance of beams, which by his followers, Saint Venant, Lamé, and Boussineeq, has been elaborated and applied to very complex problems. The first named, a student of Navier's, in his notes on Navier's *Lecons* (1857), has given a complete analysis of the strength of a beam, both within the limit of its elastic resistance and at rupture. Of this great engineer, physicist, and teacher it has been said that he "has done more than any other one to bring theory and practice into harmony, and to put both on a thoroughly scientific basis, so far as the strength and elasticity of engineering materials is concerned." It appears, however, that Saint Venant himself, with the modesty of a true savant, accredited his great work largely to his teacher Navier.

ARMATURE CORES AND SLOTS

Alton D. Adams

CHOICE OF MATERIAL—INSULATION OF DISKS—PUNCHED SLOTS—MILLED SLOTS—MILLING CUTTERS

THE armature core is one of the most important elements in a dynamo or electric motor. However perfect the machine may be in other parts, a material defect in the design or construction of the armature core renders it of little value. If an unsuitable iron is used for the disks, or if they are not properly insulated from each other, the heat loss in the core is so great as to seriously affect the efficiency and to endanger the life of the machine by the destruction of the cotton and paper insulation of the armature windings. If the number of armature slots is too small, there is a decided tendency toward sparking at the commutator. If the slots are very wide, there is serious heating in the pole pieces, unless they are also made of sheet metal.

The selection of armature iron is to a large extent a matter of trial. It is quite certain that a good iron for the purpose will be very low in carbon and impurities, and also soft and tough, mechanically; but, irons very near together in these particulars are known to give quite different results as to heat in armature cores. Very soft steel sheets have been much used by some dynamo makers, but the best grades of iron sheets are more apt to prove satisfactory in a case where each material is of untried quality. All sheets should have their scale removed.

Before final mounting on the armature shaft the disks should be covered with an insulating compound by dipping or painting with linseed oil, japan, or other suitable liquid. This insulation should be dried, either by the exposure of the disks in an oven or for a longer time in the open air. The thicknesses of armature disks in common use vary from .02 to .025 inch, but thinner iron is used in some cases, especially for machines of the alternating-current type. If the iron used is too thick, the heat loss is increased; if thinner than is necessary, the labor of handling is increased, and the room taken by the successive layers of insulation materially reduces the amount of iron that can be put into the given space. The outside as well as the center hole of armature disks is now usually cut in a press, but may be formed with circular shears in some cases. As the cost of a press and the necessary dies is considerable, builders that contemplate the manufacture of one or even a few dynamos or motors only, often prefer to get their armature disks ready-made. There are several makers of plain round disks for armature purposes, but no one, so far as the writer is aware, is prepared to furnish toothed or slotted disks. The large manufacturers of electrical machinery have, of course, their own presses and dies for their particular forms of armature slots, but their disks are not for sale.

The best course open to the manufacturer that makes only a few electrical machines, as for connections to his other products, is to buy plain disks of the required diameter and mill out the slots to suit his designs, whenever this is possible. While the cost of milling is somewhat more than that of punching slots in armature disks, when once a proper

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press and dies are secured the difference is not so great as to prevent extended use of the milling process among the smaller electrical manufacturers. The forms of slots in armature disks do not, in all cases, permit the use of milling cutters, and this has been much more commonly the case in the past than at the present time. Armature slots may broadly be divided into three kinds: those with straight sides and the same width from top to bottom; those whose sides curve or turn before reaching the periphery of the disk, so as to be narrower there than elsewhere; and those that pass through the disks below their edges, so as to leave a continuous outside surface. The first form of slot can readily be cut in the milling machine—the others, obviously, cannot. Slots of the two last named kinds, that require to be punched, were thought, some years since, to possess decided advantages, but good design has tended more and more to the slot with straight sides extending to the armature periphery. It has not been found practical to punch the complete number of slots in an armature disk at one stroke of the press, partly owing to the great cost of the necessary dies and their frequent breakage, though this method of work was at one time followed to some extent.

The standard practice in punching slots now is to cut one or a small group of slots at each stroke, and revolve the disk, between strokes, about a center fixed to an index to give the proper spacing. It is not hard to see that this process for cutting slots involves some tendencies to error in slot spacings, and as a matter of fact some large manufacturers have found it desirable to use filing machines to bring the sides of slots into line after the disks are assembled in the core.

It is highly important that the sides of slots in the completed core present no edges of individual disks out of line with the slot sides, as the insulation of armature coils, being largely paper and cotton material, is apt to be cut through by sharp or rough edges, especially as coils must fit the slots tightly, and the operation of the machine thereby ruined.

Milled slots, when the work is properly done, are not subject to the necessity of filing in order to secure smooth sides, and some compensation is here obtained for the extra cost of milling. In order to mill the slots in an armature core, the disks with their end plates complete should be mounted on a special mandrel prepared for the purpose. This mandrel should be little more than long enough to mount the complete core, so as to be stiff under the action of the cutter. The disks should be fairly tight on the sides of the key in the mandrel, as any looseness here is multiplied a number of times at the slots when the disks are assembled on the armature shaft. The mandrel should be provided with a shoulder near one end and three or four inches of thread beyond the key at the other, so that the armature disks and end plates may be crowded together between the shoulder and a screw collar on the mandrel thread.

The mandrel and armature being properly mounted on the miller, with an index head corresponding to the required number of armature slots, the cutter can be set at work. The question of milling cutters for armature slotting is of some importance, as cutters wear much faster on this work than in solid metal, owing to the traces of scale and impurities on the surfaces of the many disks that go to make up a core. The slots in common use are mostly from $\frac{3}{16}$ inch to $\frac{1}{2}$ inch wide, and from $\frac{1}{2}$ inch to $1\frac{1}{2}$ inches deep, slots usually being from two to four times as deep as wide. Side milling cutters work well for these slots and have been much used, the idea being that a plain cutter with smooth sides would be apt to stick, especially as it is customary to cut the entire depth of a slot at once. Experience has shown, however, that the plain cutter, ground for a good side clearance, is well suited to mill armature slots, and its lower cost gives it a preference over the side cutter. A rather slow speed for the cutter and a good rate of feed for the armature core have been found best suited to the work, and as a matter of economy in production several machines should be kept at work by one attendant, since a cutter will usually require from 15 to 45 minutes to cut a slot, and requires no aid. After the slots have been completed and the disks taken from the mandrel, it will usually be found necessary to run one side of each disk over an emery wheel to remove a burr that would otherwise make an electrical contact with the next disk when on the armature shaft. When the disks are assembled on the armature shaft it is important to keep the slots in line as the disks go on, as there is very apt to be a little play on the key, and it is very hard to line up the slots after the disks are all on.

The slots may be easily kept in line by using a round rod of drawn steel, whose diameter is the same as slot width, for a liner in the slots.

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A GREAT DISCOVERY

George McC. Robson, M. A.

THE HYPOTHESIS OF UNIVERSAL GRAVITATION—A BODY DOES NOT NECESSARILY HAVE A CENTER OF GRAVITY—ATTRACTION OF SPHERES AND SPHEROIDS

> What if the sun
> Be center to the world; and other stars,
> By his attractive virtue and their own
> Incited, dance about him various rounds?
> —*Milton.*

In the first eleven sections of the Principia, of which we have given an outline, Newton established a large number of very interesting theorems relating to the motions of particles; but if, in the lunar theory, the earth and moon are treated as particles, their diameters must be regarded as being so small as to be negligible in comparison with the distance between them. The distance between the earth and the moon is, however, only about thirty times the earth's diameter; and manifestly, therefore, any result obtained by regarding these bodies as particles can claim to be, at best, but an unsatisfactory approximation. If there be any mathematics worthy of study for its own sake and apart from any practical application of it, the opening sections of the Principia should be read by students of mathematics for the power of geometrical reasoning therein exhibited, and for the mathematical elegance of the solutions. But these sections do not stand alone, and their interest is not theoretical merely; the theorems of these sections are only the prelude to the yet more remarkable propositions in which Newton passed from the domain of approximation into the region of mathematical exactitude, by an investigation of the attractions of rigid bodies in which account is taken of the dimensions of the bodies.

The twelfth section of the Principia is on the attractions of spherical bodies. The first proposition of this section (the seventieth proposition of the Principia) is: *If to the several points of a spherical surface there tend equal forces varying inversely as the square of the distance, the resultant attraction on a particle placed anywhere within the spherical surface is nothing.*

In elucidation of the enunciation of this proposition it may be necessary to state that the forces tending to two points are equal, if a particle equidistant from the two points is equally attracted toward each of them. The proposition may be stated in the following equivalent form: *A uniform spherical shell of matter attracting according to the law of nature exercises no resultant attraction on any internal particle.*

It is remarkable that the law of nature is the only law for which a uniform spherical shell produces no resultant attraction on an internal particle, a principle that is very important in electrostatics.

The seventy-first proposition is: *Under the same conditions, the resultant attraction of a uniform spherical shell on an external particle varies inversely as the square of the distance of the particle from the center of the sphere.* From these two propositions Newton easily shows that, if the attraction due to each particle varies inversely as the square of the distance, a sphere composed of uniform material, or a sphere of various materials arranged in uniform concentric strata, attracts external bodies as if its whole mass were concentrated at its center. Hence, it follows also that terrestrial gravity is maximum at the surface of the earth, and diminishes as we depart from the earth's surface either upward or downward. Above the surface, gravity varies inversely as the square of the distance from the earth's center. If we suppose the earth to be of uniform density throughout, a miner in a deep mine is inside a spherical shell which exercises no attraction on him, and his weight, therefore, is due to the attraction of a portion only of the earth—namely, the smaller sphere of which his distance from the earth's center is the radius. A miner, then, should weigh less at the bottom of a mine than he weighs at the surface; but, if he should attempt to verify this statement by experiment, and were to weigh himself at the surface and at the bottom with an ordinary balance and some of those masses of iron usually called *weights*, he would detect no diminution of his weight. A moment's reflection, however, shows that the attempted

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test is no test at all, for these so-called *weights*, in descending the mine, diminish in weight exactly at the same rate as the miner's own weight diminishes. If the mine were deep enough, the loss of weight could be detected by a spring balance, but the best verification of the statement is by means of pendulum experiments. If the earth were a uniform sphere, gravity below the surface would be directly proportional to the distance from the center.

In the seventy-sixth proposition, Newton shows that, if the attraction due to every particle varies inversely as the square of the distance, two uniform spheres, or two heterogeneous spheres, each consisting of uniform concentric strata, attract each other as if the whole mass of each sphere were concentrated at its center. In the nine corollaries to this proposition he points out in detail that the propositions established in the preceding sections for the motions of particles are applicable to the motion of such spheres.

Propositions seventy-seven and seventy-eight prove that two uniform spheres, or two heterogeneous spheres consisting of uniform concentric strata, when the attraction due to each particle varies directly as the distance, attract each other as if the whole mass of each sphere were concentrated at its center. The law of the inverse square, and the law of the direct distance are the only laws of force for which such a sphere attracts an external particle (or another such sphere) as if the whole mass of the attracting sphere were concentrated at its center.

These three propositions include the most important cases of attraction of spherical bodies; the remaining propositions of the twelfth section treat of the general case of the attraction of a homogeneous sphere on an external particle under any law of force. It has been maintained that the Newtonian method of attacking these problems is as powerful and effective as the analytical method; but really the best method, in this as in other departments of mathematics, is a judicious blending of the geometrical with the analytical method; so that each is illuminated by the other. So long as geometry and algebra were kept distinct, little progress was made in either, but since their recent happy alliance they have advanced together with giant strides.

These beautiful and extremely important propositions were discovered by Newton either in January or in February, 1685. We know, from his own words, that he had not anticipated that, for the law of the inverse square, spherical bodies would be found to attract each other as if each were concentrated at its center, until this result emerged from his mathematical investigation. Then he realized for the first time that the theorems of the preceding sections, when applied to the solar system, would give not mere rough approximations, but results mathematically exact, except for a slight correction to be applied because the bodies of the solar systems are not exact spheres. But Newton would not rest even with this high achievement; this striking success inspired him to investigate the correction to be applied on account of the deviation of the heavenly bodies from true spheres, in order that mathematics might be applied to the actual problems of astronomy with absolute precision.

Accordingly, in the thirteenth section of the Principia, he grapples with the problem of the attraction of non-spherical bodies. The most important propositions in this section are those relating to the case of spheroids that differ but little from spheres. We shall have occasion later to speak of the truly marvelous sagacity he displayed in applying these results to the determination of the shape of the earth, to the explanation of the tides, and to the explanation of the cause of the precession of the equinoxes and the determination of its amount.

The fourteenth and concluding section, of the first book, contains propositions relating to the motion of minute corpuscles; these propositions are of importance in Newton's theory of light, but have no bearing on the theory of gravitation, and, therefore, we shall not enumerate or discuss them. Nor shall we enter upon any analysis of the second book, which deals with the motion of bodies in resisting media.

Before taking up the consideration of the third book, in which the principles established in the first book are applied to the actual problems of the universe, it will be helpful to make some remarks that will indicate briefly what Newton had accomplished in the first book. We shall define more clearly the meanings of some of the terms employed, and we shall state clearly what Newton assumed and what consequences he had shown would necessarily follow if those assumptions were true. In studying the history of such investigations as Newton's, there is always a danger of mixing up nineteenth-century science with

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the older science; and the student, through inability to keep clearly in mind the fact that the discoveries of the seventeenth century could not have been derived from the scientific knowledge of the nineteenth century, frequently fails to appreciate the importance and the relation of the several steps that led to a discovery. No doubt some of our readers have outstripped our narrative, and have long since completed the discovery and the demonstration of the law of universal gravitation, and have possibly discovered a good deal that would surprise Sir Isaac Newton not a little.

In any science it is absolutely essential that the terms employed shall be clearly defined, so that there shall be no room for ambiguity; otherwise the very words we employ to assist in developing the science may themselves lead us into serious error. But this definition of a term that is required for scientific purposes is not to be confounded with the complete philosophical analysis of the nature of the thing represented by the term. A philosophical definition of number is not a necessary preliminary to the science of arithmetic, nor is a correct definition of life a requisite condition for the first beginnings of the science of medicine; there are some expert arithmeticians that could not define number, and there may be doctors licensed to practice medicine to whom a philosophical definition of life would convey no more meaning than the hieroglyphics on an Egyptian monument. It is fortunate that philosophical definitions, however important and valuable, are not essential to science, at least in its beginnings; for the philosophers have never been able to agree on the definitions of some of the things that lie at the very foundation of all science. The definitions we are about to discuss, then, do not pretend to be philosophical definitions; but merely such specification and explanation of the meanings of words as will insure that, when two people use the same word it shall suggest the same idea to both, assuming that both have the idea. To illustrate what we mean, we may suppose an Englishman and a Frenchman to meet somewhere; both of them possess the idea that corresponds to the English word *number;* but, before they can communicate numerical ideas to each other, it is necessary that one of them should learn what sounds or written symbols call up those ideas to the mind of the other.

Matter is known to us by our sense-perception of some of its properties—such as extension, hardness, and resistance; a body is a limited portion of matter. The first definition of the Principia is: *The quantity of matter in a body is equal to the product of its volume and density.* Newton's illustration of this definition is that, if one body of air is twice as dense and occupies twice as much space as another body of air, the quantity of air in the first is twice as great as that in the second. In further comments he says that the term *mass* is synonymous with the phrase *quantity of matter.* We have here a clear statement of the relation between mass and density; so that, if there is any method of measuring mass, this definition supplies a method of measuring density. The term *mass*, however, cannot be used as in the Principia unless it is possible to define what is meant by *equality of masses;* for without this definition masses cannot be measured or represented by numbers, and therefore cannot be dealt with algebraically.

So long as we are dealing with only one kind of matter there is no difficulty in interpreting the statement that two bodies A and B contain equal quantities of matter. It is evident, from Newton's illustration, that the equality of the masses of A and B cannot be tested by measuring their volumes; unless, indeed, these are measured under exactly similar conditions with respect to the things that would cause a change in the volume of a body. The precautions adopted to secure uniformity in this respect are never perfectly effective; and, in some cases, unavoidable alterations in the circumstances produce a considerable variation in the volume of a body. On the other hand, the weight of a body, determined with due precautions and at the same place, is always sensibly the same; and, therefore, for practical purposes the equality of the masses of A and B can be tested by weighing. Though the masses of A and B may be compared by means of their volumes or their weights, yet the mass of the body A is neither its volume nor its weight; the mass of A is invariable, however its volume or its weight may alter with circumstances.

If all apparently different kinds of matter were composed of some single substance, and any kind of matter might conceivably be converted into any other kind, any two bodies containing equal amounts of this fundamental substance would have equal masses, and a real equality of quantity of matter between air and steel would be possible. If this theory of matter is correct, the

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alchemists' dream of transmuting the baser metals into gold may yet be realized.

Apart from some such hypothesis there can be no real equality of quantities of matter of different kinds. It is necessary, therefore, to consider whether Newton's theory of matter, though not referred to in the definitions of the Principia, throws any light on this question. His idea of the constitution of matter was: "It seems probable that God, in the beginning, formed matter into solid, hard, impenetrable particles, of such sizes, figures, and with such other properties, and in such proportions to space, as most conduced to the end for which he formed them; these primitive particles, being solid, are incomparably harder than any porous body composed of them; even so hard as never to wear or break in pieces, no ordinary power being able to divide what God himself had made one in the first creation." It is not easy to see how this doctrine could lead to the idea that any real equality exists between quantities of matter of different kinds; nor does Newton employ it to explain how masses of different kinds may be compared. It appears, then, that a satisfactory method of estimating equality of masses cannot be obtained from the first definition of the Principia, even by reading into it Newton's conception of the constitution of matter. Newton's final comment on this definition is that mass is proportional to weight, as he had proved by experiments, which are described in the third book of the Principia. The proportionality of weight and mass is not given as an assumption or a definition, for he says distinctly that he had proved it experimentally.

The justification of the use made of the term *mass* throughout the Principia not being found in the first definition, we shall seek to discover it by examining the third definition in the light of one of the rules by which Newton professes to be guided, which is: Any property that admits neither of increase nor of decrease of degree, and is found to pertain to all bodies within reach of our experiments, is to be esteemed a property of all bodies; this is the foundation of all philosophy, for the properties of bodies are known to us through our senses and not by our reason. As far as possible, therefore, we must avoid embodying theories in the definitions of the properties of matter. We know by experience that force must be applied to a body at rest to set it in motion, and force is also necessary to bring a moving body to rest. Hence, in the third definition Newton says that every body possesses a property called *inertia*, which is a capacity for resisting any effort to change its state of motion. This property affords a method of comparing quantities of matter of the same kind without reference to weight or volume; for it is evident that two bodies of the same kind have equal masses if they receive equal changes of motion from the application of the same force. It is known by experiment that a spring compressed to less than its natural length exerts force, and will not remain in compression unless force is applied to each end. If one end of a spring were fixed and the other end were applied to a free body at rest, the force exerted by the spring would cause the body to move; it is assumed that, whenever the spring was compressed to a certain extent and applied to the same body, the motion generated would be the same; i. e., the body would move from rest through equal spaces in a unit of time. This assumption is verified by experiment. We can, therefore, use a spring to reproduce the same force as often as we desire.

The idea of equality can now be extended to quantities of matter of all kinds by the following arbitrary definition or assumption: *Two bodies have equal masses if the same force produces the same motion in each of them.* Newton nowhere explicitly states this assumption, but it is implied in his remark, in connection with the third definition, that the inertia of a body is proportional to its mass. On this assumption his second law of motion is an easy generalization from experience, and becomes an axiom of mechanics as he calls it.

Equality of masses, in accordance with this assumption or definition, is real or merely conventional, according as the two bodies are, or are not, of the same kind of material. Two things may be said to be conventionally equal or equivalent from some point of view, if in that aspect they have identical properties. This definition of equivalence, or conventional equality, implies a limitation of the purpose for which the things are compared—for the particular purpose in view, two equivalent things may be used interchangeably. From the point of view of exchange value, a silver dollar is equivalent to a dollar bill, but there is no true equality between the silver coin and the paper dollar; if we choose to say that the piece of silver and the piece of engraved paper are equal, we can only mean that in commercial transactions the coin or the bill can be used indifferently. The criterion of

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(conventional) equality of masses has regard only to the motions received by the bodies from the action of the same force, and not to their volumes, weights, or other properties.

The use of the term *mass* in the Principia is entirely consistent with these principles; though it is certain that, if Newton had developed his views at length for the benefit of a tyro in science, his exposition would have differed from that given above. The definition of equality of masses furnishes a theoretical method of measuring mass that is a sufficient basis for the propositions of the Principia; but, in practice, as Newton says, masses are compared by weighing. Therefore, it is necessary to prove that weight and mass are proportional, when mass is measured in accordance with the preceding definition, or, which is the same thing, that the proportionality of weight and mass can be deduced from the second law of motion.

Though equality of masses may be determined by weighing, yet mass and weight are not synonymous. The mass of a body is the same at all places and under all circumstances; but the weight of a body varies when the body is carried from place to place, as we have seen in our analysis of the twelfth section of the Principia. There is a certain piece of platinum carefully preserved by the British Government, and officially described as the British Imperial Standard Pound, which is commonly spoken of as a unit of weight; but which is, in fact, a unit of mass and is so described by all scientific writers. This piece of metal is a satisfactory unit of mass; for its mass is the same whether it is in London, at the bottom of the Atlantic Ocean, or on the top of the Rocky Mountains. But the weight of a piece of metal is not a satisfactory unit of weight, for we can alter the weight of the piece of metal by simply carrying it upstairs or downstairs.

Since the weight of a body is the force with which the earth attracts the body, weight should be measured, not by units of mass, but by units of force. The correct principles of metrology were first expounded by the illustrious German mathematician Gauss, who proposed a system of units which he called the *absolute* system. In the absolute system, arbitrary units of length, mass, and time are chosen; and all other physical quantities are expressed in terms of units derived from these three arbitrary fundamental units. The absolute unit of force is defined as that force which, acting uniformly for a unit of time on a unit of mass, produces a velocity of one unit of length per unit of time. In the British system of measures, the absolute unit of force is that force which, acting uniformly for one second on the British standard pound, produces a velocity of 1 foot per second; this unit of force is called a *poundal*. If the standard pound were allowed to fall freely, the force acting on it would be simply its weight; and its weight acting on it for one second would generate in it a velocity of about 32 feet per second; hence, the poundal is approximately equal to one-thirty-second part of the weight of a pound; or, the poundal is nearly equal to the weight of half an ounce. A force, however, is usually expressed as being equal to the weight of a certain mass, and is then said to be expressed in *gravitation measure*. Though inexact, the gravitation measure of force is very convenient; it is used almost exclusively in books written by or for engineers, as it is sufficiently accurate for all engineering purposes.

Newton's test of the proportionality of weight and mass was made by pendulum experiments. He constructed two exactly similar round wooden boxes, and suspended them by threads 11 feet long; one of the boxes he filled with wood, and in the center of oscillation of the other he placed a quantity of gold; so that he had two pendulums perfectly equal in weight and figure and equally receiving the resistance of the air. Causing these two pendulums to swing side by side, he observed them vibrate together for a long time with equal vibrations, thereby proving that the masses of the two pendulums were equal; that is, equal weights of wood and gold have equal masses. Newton also experimented with silver, lead, glass, sand, common salt, water, and wheat. These experiments were repeated with the utmost care by the great astronomer Bessel, who presented his results to the Berlin Academy in 1832.

If every particle of a body is acted on by a force, and if all these forces are equal and parallel, the effect of these forces on the body is equivalent to the effect of a single force acting at a point fixed relatively to the body, and this point is called the *center of mass* of the body. In ordinary problems dealing with small bodies, we regard the weights of the several equal particles of a body as constituting a system of equal and parallel forces, and we speak of the center of mass of a body as its *center of gravity*, and say that the weight of a body is equivalent to a

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single force acting at its center of gravity. The weights of the several particles, however, do not constitute a system of strictly parallel forces; and, therefore, it is not correct to speak of the center of mass of a body as its center of gravity. The true definition of center of gravity is as follows: When a body is such that it attracts matter external to itself as if its whole mass were concentrated at a definite point, that point is called the *center of gravity* of the body, and the body is said to be *centrobaric*. From the twelfth and thirteenth sections of the Principia we learn that a sphere composed of uniform concentric strata is a centrobaric body; but a spheroid is not centrobaric, and has no true center of gravity, though it has a center of mass. In the preceding articles of this series we have followed the almost universal custom of speaking of the center of gravity of a body or system, when really we meant to refer to its center of mass.

Let us now consider what Newton had accomplished in the first book of the Principia. As the foundation of the whole structure he took the three laws of motion, which he accepted as incontrovertible facts. Then he frames the hypothesis: Suppose a particle is attracted toward a center with a force that depends on its distance from the center; he works out the consequences of this hypothesis, and determines what the motion of the particle would be, giving particular attention to the case in which the force varies inversely as the square of the distance. Then he frames a new hypothesis: Suppose two moving particles attract each other with a force depending on the distance between them; and he develops the consequences of this hypothesis. Again, he frames another hypothesis: Suppose every particle of one body attracts every particle of another body with a force depending on the distance; and he derives the consequences of this hypothesis for the cases in which the bodies are spherical or nearly spherical. Of course, Newton did not develop all the consequences of any of these hypotheses; in each case he considered chiefly the motions that would take place under an attraction varying inversely as the square of the distance, and was satisfied with such results as would enable him thoroughly to test his hypothesis by comparison with the observed facts of the solar system. In the first book of the Principia general propositions only are given, without numerical calculations or results —the occasional references to the actual problems of astronomy are incidental merely. His design in this book was to develop in general terms the broad consequences of his hypotheses, reserving for the third book that comparison with the facts which would determine whether his hypothesis harmonized with and explained the phenomena of the solar system.

We shall now state in its modern form the hypothesis whose validity is discussed in the third book: *Every particle of matter attracts every other particle with a force that acts in the straight line joining the two particles, and that varies directly as the product of their masses and inversely as the square of the distance between them.*

This is called the hypothesis of universal gravitation. In the enunciation of the hypothesis of universal gravitation it is implied that the dimensions of each particle are infinitely small compared with the distance separating it from any other particle —otherwise the terms *line joining the two particles* and *distance between them* would have no meaning. The twelfth section of the Principia, however, enables us to remove this restriction when the particles are homogeneous and spherical; in this case the line joining two particles means the line joining their centers, and the distance between them means the distance between their centers.

Keeping these limitations in mind, we can reduce the hypothesis of universal gravitation to an algebraic formula. Let two particles whose masses are m pounds and m' pounds be placed at a distance of r feet apart; and suppose the mutual attraction of these two particles to be F poundals; then, the hypothesis of universal gravitation is expressed by the formula

$$F = \frac{kmm'}{r^2}, \qquad (1)$$

where k is a constant, independent of the magnitude of the masses and their distance apart.

We have said that Newton reserved the discussion of the validity of this hypothesis for the third book; but, of course, throughout the investigations of the first book he had caught glimpses of the harmony of his assumptions with the facts of nature; and these prophetic glimpses had undoubtedly convinced him that he was marching to victory.

There are two questions to be decided: *first*, Does every particle of matter attract every other particle? and, *second*, Is the law of this attraction correctly expressed by formula (1)? The most natural thing in the world is to seek the answer to these

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two questions in the experimental laboratory. It would seem that there could be little difficulty in deciding the first question definitely and conclusively by observing whether two spherical masses actually do attract each other. Suppose this question to be experimentally decided in the affirmative, the next step would be to measure very carefully the amount of attraction between various bodies under different conditions, and thus determine whether k in formula (1) is a constant or not. If the values of k, thus determined by experiment, differed very widely, we would know that the second question must be answered in the negative; but, if the results indicated that k is constant, or nearly constant, it would be impossible to decide whether formula (1) is exactly or only approximately true; for, all actual measurements are merely approximations.

Why, then, did Newton, who was an eminently skilful and successful experimenter, seek to verify his hypothesis by the motions of the planets and their satellites, instead of resorting to the simple and direct method of experiment? The reason is that Newton, by some sort of prophetic instinct, realized that the attraction between any two manageable masses must be so small that it could not be detected by any experiment that was then possible, and therefore experiments could yield only negative results, and the only conclusion to be drawn from such negative results would be that the attraction, if any, is very small. Such an experiment was, indeed, performed about the end of the eighteenth century by Cavendish, employing a very delicate torsion balance invented by Michell, which is similar to the well-known torsion balance invented independently by Coulomb. The Cavendish experiments fully confirmed the hypothesis of universal gravitation, and they also confirmed the wisdom of Newton in declining to submit the question to experimental test. To show the soundness of his judgment in this matter, we shall anticipate a little, and assume that formula (1) expresses a true law of nature.

If we can measure the attraction between two bodies, say two cannon balls, of known masses, we can then determine the value of k in the formula. Then when k is known we can, from the known attraction of the earth on a given mass, determine the mass of the earth in tons or pounds. The chief object of the Cavendish experiment was to determine the mass of the earth. Several other methods have been used for this purpose, but they all depend on the truth of formula (1). The mass M of the earth is about $6{,}067 \times 10^{18}$ tons; which makes its average density or specific gravity about 5.5. Of a large number of careful determinations of the earth's density the smallest is 4.713, and the greatest is 6.565. Moreover, if M is determined by any method, the value of k in formula (1) can be determined; assuming M to be $6{,}067 \times 10^{18}$ tons, we find k to be $1.038 \div 10^9$, nearly. Using the formula with this value of k, we can calculate that the attraction between two spherical balls, each of 50 pounds mass, with 1 foot between their centers is less than one-ten-millionth of the weight of a pound. So small a force as this can be detected and measured only by the most delicate instruments in the hands of a skilled and judicious experimenter; and it was utterly impossible that it could have been detected by an experiment that could have been performed by Newton or his contemporaries.

Newton's prudence in avoiding experiment was due simply to the clearness of his intuitions; for he had practically nothing to guide him to a correct estimate of the probable smallness of the attraction between two small bodies. No attempt had then been made to estimate the mass and density of the earth; in the course of the investigations of the third book, Newton makes the assertion that, when determined, the density of the earth would be found to be between five and six times that of water—a very remarkable guess.

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CHAINS AND THEIR USE

H. Rolfe

THE DIFFERENT LOADS A CHAIN HAS TO CARRY—ANNEALING OF CHAINS—WELDLESS CHAINS—RELATIVE STRENGTH OF OPEN-LINK AND STUD-LINK CHAINS

THE three kinds of load that may act on a body are: a steady load, a live load, and a shock. These different kinds of load are often mentioned in engineering books. Some explanation of them here follows: In Fig. 1 (*a*), the cord *c* carries a tray that is loaded with a total weight *W* put into the tray a little at a time; if the sectional area of *c* is one-half a square inch, and the total load *W* is 100 pounds, then the stress in *c* will be 200 pounds per square inch of section, and the effect on the cord is that of a *steady load*. In (*b*) the three cords *c*, *c'*, *c''* supporting the load *W* are all stretched equally taut, each carrying one-third of *W*, or 33⅓ pounds. If *c'* and *c''* were suddenly cut,

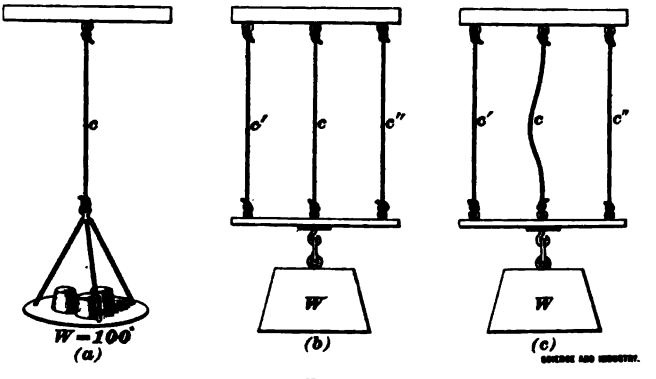

FIG. 1

throwing all the load onto *c*, the stress induced in *c* would be 200 pounds, or 400 pounds per square inch, and the effect is that of a *live load*. In (*c*) the cords *c'* and *c''* carry the load, the cord *c* hanging slack. If, now, *c'* and *c''* were to be cut, allowing *W* to fall, the load would all come suddenly on the cord *c* and subject it to a *shock*, the stress induced being very much greater than before. What it will actually be cannot be stated; it all depends on the distance through which the load falls and the space through which it is arrested—this latter being the amount that the cord stretches.

Now, the treatment that the majority of crane chains occasionally undergo—as when the links override and then slip—corresponds to case (*c*), and we cannot say what the stress in the chain may be. The amount of stretch depends on the time the chain has been in use, or, at least, on the time that has elapsed since the last annealing. The reader will perceive how important the item of ductility is by imagining a chain made of glass. Obviously, such a material *could* be employed if tensile strength were all that was required; ordinary untoughened glass is quite as strong as leather belting for a steady load; but one feels intuitively that such a chain would be very short-lived, and want of ductility is the cause.

Annealing the chains restores them in a great degree to their original condition, renewing their power of "give" or "stretch," although somewhat decreasing their tensile strength. This annealing consists of heating a chain to a cherry red and allowing it to cool slowly; the operation serves a double purpose, for it also opens out any incipient cracks. When the chain is cold, it is examined link by link to search for these flaws; also, any link found to be unduly stretched should be cut out, for, evidently, that particular link is weaker than the rest. When thoroughly examined a chain is given a coal-tar bath to preserve it from rust, and it is then ready for use. Chains receiving careful treatment and working under favorable conditions need only be annealed every twelve months. Coal-whipper chains and others receiving rough and thoughtless treatment ought to be drawn through the fire at least once every six months. The process of annealing should not degenerate into a farce, as is sometimes the case, by making the chains not much more than black hot. They ought to be made a cherry red. Strictly speaking,

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however, this does not fix the temperature definitely, because it depends on the light in which the work is done, and also on the eye of the workman doing it. Speaking with all the links stamped to shape but held together by a thin web. This is subsequently cut out and the links thus separated from one another. They are then

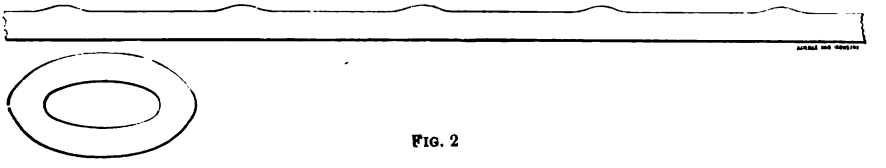

FIG. 2

definitely, we would specify 1,350° F. as the proper temperature. As, however, a thermometer does not form part of a chainsmith's kit (and he couldn't make use of it if he had it), we can only say that the chains should be heated to a cherry red.

Chains should be taken out of service when the links are much worn at the ends; it is sometimes practicable, however, to put them to work on a smaller crane, and so prolong their working life.

In some countries chains are tested and stamped at proving establishments; in one case we know of this is done by the government. Makers usually furnish a guarantee with every consignment of chain, but it is well to make a test for oneself by breaking a link or two on the anvil—not choosing the end links either, as those may have been made of superior iron for the purpose.

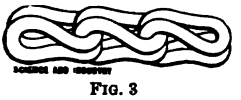

FIG. 3

Owing to the end of a link being the weak part, a course that naturally suggests itself is to roll the iron with enlargements or thickenings at intervals, according to the length of link before bending, these enlarged parts to occur at the ends when welded up (see Fig. 2). This method might make them more expensive as regards first cost, but they would certainly have a longer life.

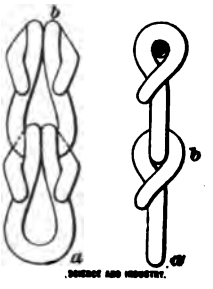

FIG. 4

Weldless chains are now made of steel. Generally they are rolled out of a solid piece. The two rolls have recesses all around their peripheries that come together and enclose a space the shape of the link required. At the last stage of the rolling, when the rolls are quite close to each other, the chain is still in one connected piece, finally trimmed up. All loss due to welding is avoided by this method.

Weldless chains have also been made by using links formed as follows: A hole is punched in a piece of flat plate, which is then spun up until the rectangular section becomes a round one. The link is next pulled into an elongated shape and then bent over double around another one similarly treated, the result being a chain with weldless links. (See Fig. 3.)

FIG. 5

Small chains are sometimes made with links as in Fig. 4, which shows what is called a *jack* chain. There is no weld in it; each piece of bar iron constituting a link is bent round to form loop *a*, then both ends are doubled over to form the other end *b* and the loose ends crossed and pressed against the face of the link. Fig. 5 shows a similar kind of chain. Also, small welded chains are sometimes made like that in Fig. 3. The links are made of bar iron as usual, and of extra length, and then doubled over one another in the form shown. It will be noticed here that there is one weld in the link, but it only affects one-quarter of the total section of the chain instead of one-half, as in ordinary links. These links have two advantages: they can be bent so that the weld occurs at the side; and, the chain being smaller in section, the bending action is not so severe—the stress, in fact, is more uniformly distributed over the section. These chains, especially that in Fig. 3, show, in the testing machine, a considerable excess of strength over the ordinary type.

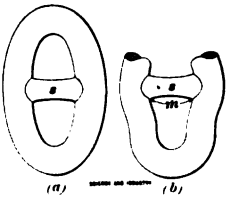

FIG. 6

Among small chains, the kind shown in Fig. 5 is a very effective design. There is no

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weld in it at all; the links are composed of lengths of bar iron, and the ends bent as shown. The breaking load of this chain is about twice that of the common welded variety.

Crane chains are usually of the close-link type; cable chains are of the stud-link type. Considerable difference of opinion exists as to whether these latter links are stronger than the open variety. One government we are aware of employs a proof test 50 per cent. greater for the stud than for the open variety; but this test has been severely criticized by the experts of other governments, who claim to have found the stud link to be the weaker of the two. It does not necessarily follow, however, from the adoption of the above test, that this variety was regarded as the stronger; it may have been because the stud-link chains will stand a higher test than the open-link without collapsing. The latter would lengthen, and at the same time decrease in width; whereas, in the other case, the studs prevent the sides of the link from coming together. Still, the stud *may* possibly be a source of weakness in this way: When the link shown in Fig. 6 (*a*) is subjected to a severe pull the sides tend to close in, but the stud *s* resists their doing so, causing the link to assume a shape something like that in Fig. 6 (*b*), thus inducing a severe nipping action at *m*, the junction of the stud with the link, at which points the sides abruptly lose the support of the stud. In the open link, when approaching rupture, the link would be as in Fig. 7 (*a*). Here the sides *A*, *A* are parallel, and if *W* is the total pull, there will be a pull of $\frac{1}{2}$ *W* in each bar of the link. But in Fig. 7 (*b*) the two sides of the link will, under a severe load, form an angle, and the larger this angle, the greater will be the stress in the link. It is not a fair pull, as in the other case. If *b c* represents the pull in an open link, *a c* will represent, to the same scale, the pull in the stud link under same conditions of load, so that when tested to destruction, and therefore undergoing the above distortion, the stud link may actually prove to be the weaker—a result contrary to general belief.

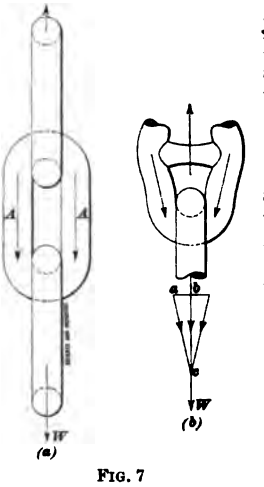

FIG. 7

VALUE OF STOP-COCKS IN PLUMBING

A Knight of the Cloth

WHERE THEY SHOULD BE LOCATED—HOW THEY SAVE MORE THAN THEIR COST—THE STOP-COCK A HOUSEHOLDER'S FRIEND

THE value of a stop-cock is not the price of a stop-cock, any more than the value of a drink of water is the price of the water. The value of either is, beyond doubt, far in excess of their cost. If you think this is not so, just get along without water for a few days, or try to put a washer on a kitchen faucet with the pressure on; or, what is equally effective, talk to any house-owner that has had the never-to-be-forgotten experience of being rudely awakened at 2 A. M. by the weird hissing of a leaky pipe, and, with a candle in his trembling hands and his nocturnal robes fluttering behind like a flag of distress, has run from attic to cellar repeatedly, in the vain hope of finding a stop-cock to shut off the water before the house becomes flooded. Or, if you cannot find such a man, just step into a reputable plumber's shop and ask the *value of a stop-cock*. If he is straight, as most of them are—"Puck," "Judge," and the "New York Journal" to the contrary, notwithstanding—he will tell you that every stop-cock he has yet put in has paid for itself over and over again; he does not imply by this that his jobs will not spring a leak any more than any other plumber's jobs, for they will all break out once in a while. If he is a strictly up-to-date plumber, as many are, and as all should be, he will tell you with pardonable pride that he takes a delight

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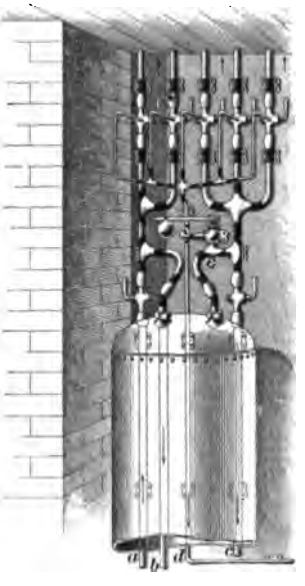
in placing stop-cocks to control every faucet on the job. "This," says he, "gives us a chance to regulate the supply of water to baths, basins, sinks, water closets, etc. as we see fit, and as the street pressure and other conditions demand, and it not only prevents splashing and certain noises, but also gives the householder a chance to shut off the water himself when anything goes wrong."

If you own a house and have had a few stop-cock experiences, you will naturally chime in, "Good idea, Mr. Plumber; but what is the cost of such stop-cocks?" The plumber will hesitatingly tell you that, if you get them put in when the plumbing job is being done, it will cost practically nothing—only about a dollar or so each. But if you want them put in as an "afterthought" it will cost you somewhere about two or three dollars each. "But," continues the plumber, after he has quietly studied your countenance and decided that you cannot afford to stop-cock all fixtures up home just now, "whether my customers order stop-cocks at the fixtures or not, I always put them on certain places where they may control the distributing lines, and, of course, indirectly, the faucets also. I do this to protect the building in case of leaks. And I tie little brass tags on each stop-cock, so that my customers can handle them intelligently." You now show such an interest in the thing that the plumber plunges into a dusty old filing case and brings out a photograph showing the stop-cocks over a kitchen boiler he put in a few years ago. "There," he says, handing you the print, "are the stop-cocks on one of my pet jobs." Of course you admire the neat workmanlike arrangement of the pipes and cocks, and would ask a few questions about the use of all these cocks, but you are rather timid lest this man of stop-cocks turn you down as one that knows nothing about plumbing. Don't be afraid; he knew that the moment you came in the door, and therefore will proceed to explain the photo.



"This pipe," he may remark, pointing to *a* in our sketch, "is the cold-water pipe that supplies *cold water* to the kitchen boiler, the butler's pantry on the first floor, and the bathroom on the second floor. The stop-cock on *a* shown under the boiler-supply branch is labeled, so that the range, boiler, hot water for whole house, and cold water to upstairs, may be shut off here." He may also say that this cock is usually placed on the branch instead of on the rising line, so that it may shut off the boiler and hot-water supply system only, without affecting the cold-water service anywhere in the building.

He will draw your attention to the five stop-cocks all in a row over the boiler, and tell you that this is the way he likes to see them put in, instead of being scattered all over the job where nobody can find them except the man that put them in. He may tell you that the cook can turn off the water for any section of the building just as well as the most intelligent plumber in town, if she goes by the tags. And in case of a leak, she can do it before much damage is done.

"But," you ask, "what is that network of small tubing attached to the stop-cocks?" And he will answer, "To drain the pipes empty when they are shut off." Then you might become overanxious for information, and ask him, "What about that lever thing with the ball on its end," and he will graciously say, "It is a safety valve, and has nothing to do with stop-cocks at all."

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USEFUL IDEAS

AN EMERGENCY PRINTING FRAME

We are indebted to Mr. C. T. Catillas, Chief Engineer of the State Hospital at Middletown, N. Y., for the following suggestion of a method of making blueprints that we think will prove useful to many that find themselves in a position where it is desirable to make a print of a tracing but have no suitable printing frame at hand. A single-light window sash *a* forms the frame and glass; a board *b*, cut to fit in the sash and thick enough to project a little beyond it, as shown in the sketch, forms the backing for holding the tracing and paper in place; finally, the backing board is held firmly in place by a strip of wood *c* fastened to the sash by a screw through each end. A cushion made of heavy felt, or several thicknesses of soft cloth placed between the board and the paper, completes the outfit, and makes a very satisfactory printing frame.

ANOTHER USE FOR THE HAMMER HANDLE

J. E. Overbeck, Cincinnati, Ohio

Under the heading of Chips and Spalls, in the November issue of Science and Industry, I noticed the scheme of Mr. Bogue for carrying a nail set in a hammer handle. I think this is a good idea, but I find the end of my hammer handle much more preferable for carrying beeswax. For instance, I bore a $\frac{1}{4}$-inch hole in the end of the handle, filling it full of the wax, and when I wish to drive a nail in any kind of hard wood, without boring, I stick the nail in the wax, which lubricates it and causes it to drive comparatively easy. The wax may be kept soft in winter by adding to it, while in a melted condition, a little machine oil. I find this keeps it soft in the coldest weather.

SUGGESTIONS FOR THE PROPER ARRANGEMENT OF GAS-PIPING WORK

Wm. Paul Gerhard, C. E.

Gas Service.—To be of wrought-iron pipe, of ample size; to be run into the building with pitch back to street main, where possible; or else to be provided with siphon, or drip pipe and emptying plug, where service must necessarily be graded toward the house. Service pipe to be protected from frost wherever necessarily exposed.

Gas Meter.—To be preferably a dry gas meter; to be of ample size; all connections to be preferably of wrought-iron pipe and tube of full bore; fittings to be beaded malleable-iron fittings; no lead meter connections to be used. Meter to be set in a cool, ventilated, well-lighted place, easy of access, but protected from accidental injury.

House Gas Piping.—To be of a good quality of welded wrought-iron pipe, preferably galvanized. Steel pipe, being somewhat brittle, is not so good. Lead gas pipes should not be permitted. Cast-iron pipe is sometimes used for services larger than $2\frac{1}{2}$ or 3 inches in diameter. All pipe to be examined and blown into before use, to guard against obstructions.

Pipe Fittings.—To be of malleable iron, preferably beaded fittings; fittings to be selected and examined for sand holes. Galvanized fittings to be preferred. In making turns or bends, use fittings in preference to bending the pipe.

Joints.—To be screw joints. Use red and white lead mixed, or boiled linseed oil in joints. Use precaution not to get lead on the inside of joints. No gas-fitter's cement to be used on joints under any circumstances. The practice of rusting up the pipes by filling the gas pipes with water is bad, and should be prohibited. Unions should be avoided; if required, use ground joint union fittings. No washer joints should be permitted. All joints must be made absolutely tight.

Shut-Offs.—Use the best quality heavy brass work; round-way, ground-key lever cocks are preferable to valves, as they indicate at once,

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by position of lever, whether the pipe line is open or shut. Valves, if used, should be soft-seat brass valves. Iron valves are not to be permitted, as they quickly corrode from the action of the gas.

Hooks, Straps, and Clips.—All pipes to be well fastened by hooks, straps, or clips of wrought iron—not of cast iron. Use screws for fastening pipe holdfasts; no bent nails or common hooks should be used to hold gas pipes in position.

Cutting of Floor Joists.—This should never be done by the gas-fitter; the carpenter to do all cutting, and beams should not be notched, bored, or cut more than 2 inches in depth, and never farther away from wall or bearing supporting the beams than 2 feet.

Sizes of House Pipes.—No pipe to be less than ⅜ inch; it is better to make ½ inch the minimum size. In determining sizes of pipes, follow Table I for sizes of house pipes for gas lighting, and Table II for sizes of gas pipes for gas ranges and gas logs. Make all piping ample in size.

TABLE I*

Sizes of Gas Pipes, Maximum Lengths and Maximum Number of Burners (at 6 cubic feet each)

Diameter of Pipe. Inches.	Maximum Length. Feet.	Maximum Number of Lights.
¾	20	2
½	30	3
¾	40	6
1	60	10
1¼	70	15
1½	100	30
2	150	60

TABLE II*

Sizes of Gas Pipes for Gas Logs and Cooking Ranges

Diameter of Pipe. Inches.	Maximum Length. Feet.	Gas Required for
½	100	1 cooking burner or 1 gas log.
¾	100	2 cooking burners or 2 gas logs.
1	100	Gas cooking stove with 4 burners or 4 gas logs.
1¼	100	Larger gas ranges or 7 gas logs.

Gas logs and burners of cooking ranges are assumed to have a consumption not exceeding 35 cubic feet per hour. For a larger consumption, increase the size of pipe supplying log or range.

Arrangement of Gas Piping.—No risers to be placed in outside walls. No riser to be less than ¾ inch. A number of separate risers is desirable; these should be connected at the top for a better circulation of the gas, and to avoid undue variation in the gas pressure. Another method is to have separate risers for each floor. For gas logs in fireplaces, run entirely separate risers, one for each vertical group of fireplaces. Provide a separate riser for the gas cooking range in the kitchen. A separate meter for gas used in cooking or heating is also desirable. Larger risers to be kept exposed in closets; smaller pipes to be tested before being covered up or plastered over. Running lines in floors to be kept accessible by floor boards secured with brass screws instead of nails. Run all branches for side lights up from below, and do not drop them from above (except in the cellar). Place no running gas lines under tiled floors or hearths. Run no gas pipes through flues. Supply drop lights from branches taken off from side or top of running lines; never drop the branch from the bottom of a line. All horizontal gas pipes to be run with sufficient fall back to the riser; the horizontal run at cellar ceiling to have a fall toward the gas meter. All long horizontal runs between floorbeams to be well supported to avoid sagging and traps. Avoid all condensation of gas in pockets or depressions. Keep gas pipes and risers away from pipes or flues of the heating apparatus.

Gas Outlets.—Place no gas outlets behind doors or too near window trims or curtains. Place outlets for side lights at proper height, and center lights in the exact center of the room. At completion of gas piping, check off all gas outlets from plans. Make all nipples and drops plumb, and of proper length for the fixtures.

Test of Gas Piping.—The entire gas piping, when completed, and before plastering is begun, to be tested by gas-fitter with air pump and mercury gauge (22 inches long); spring gauges are not reliable. Test the piping under a pressure equivalent to a column of mercury in gauge 18 inches high (9 pounds pressure). Mercury in gauge must stand 1 hour without indicating a greater fall than ¼ inch per hour. All leaks and defects which the test reveals to be searched for with ether or by the application of soap suds, and same to be made good by gas-fitter. No split pipe or broken fitting, or fitting having sand holes, to be repaired with cement or solder. In large buildings, test gas piping in sections. After the test, have a number of capped outlets

*Quoted from the "Engineering Record."

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opened slowly, on each of the floors, to make sure by the falling of the mercury in the gauge that the entire piping has been under the test, and that no parts are accidentally or intentionally disconnected. After test, leave all outlets capped tightly.

When alterations in the gas are made, or additional lights are put in, test the altered work in same manner as in the first test.

Before the gas fixtures are hung or put up, the gas-fitter to repeat the test in the presence of the contractor for the gas fixtures, so as to demonstrate to him the tightness of the entire piping. This leaves the fixture man responsible for any leaks discovered when the gas is first turned on at fixtures. After fixtures are hung, the contractor for the fixtures to apply another pressure test with 3 inches of mercury in gauge.

The following literature on the subject is recommended: "Gas Piping for Buildings," published by the "Engineering Record," New York, September, 1894; Gerhard's "Gas Lighting and Gas Fitting," 1893; "Specifications and Rules for House Piping," issued by The United Gas Improvement Company, Philadelphia Gas Works, 1899; Public Statutes of Massachusetts relating to gas-fitting, and revised regulations pertaining to gas-fitting, 1898; Rules and Regulations of The Denver Consolidated Gas Company; Rules of the Fire Marshal of Pittsburg for piping for natural gas.

FOR DRAFTSMEN

Wm. C. Terry, North Adams, Mass.

HAVING a considerable number of drawings to trace and letter in the course of a year, I have found the following schemes to be useful when a neat drawing is wanted. Most

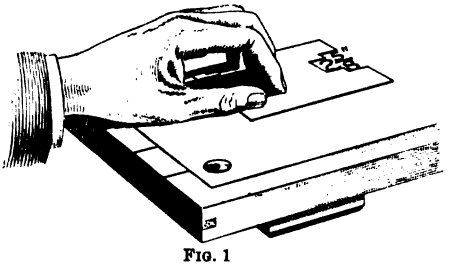

FIG. 1

draftsmen, when placing the dimensions on a drawing, fail to get them all of a uniform height, being influenced by the surrounding lines and spaces. I have overcome the trouble by using a templet, as the ordinary scale or rule is impracticable. The templet made like the accompanying sketch, Fig. 1, is cut from a thin piece of bristol board, or, what is better, a piece of thin celluloid. The shorter space, or notch, is a trifle more than the required height of the whole numbers, while the larger, or outer, one is right for fractional numbers.

The writer will mention for the benefit of beginners in drafting that he uses $\frac{1}{8}$ inch and

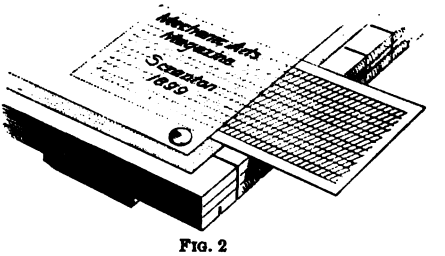

FIG. 2

$\frac{3}{16}$ inch, respectively, for the height of whole and fractional numbers. The templet is held and moved over the drawing by the left hand, while the lettering is being done with the right hand, in the usual manner.

Fig. 2 represents a method of obtaining a constant angle for freehand lettering on tracing cloth. Rule a piece of tough drawing paper, about 4 in. $\times$ 6 in., with horizontal and slanting lines. The horizontal lines are spaced alternately to correspond with the desired height of letters, and the space between the lines of lettering. The slanting lines serve as guides for the upward and downward strokes of the letters. An angle of 70° with the horizontal is very good. Place the ruled sheet directly under the tracing cloth or tracing paper, and adjust the sheet until the horizontal lines upon it are parallel with the horizontal lines of the drawing. After the lettering is sketched in with pencil, a very fair freehand letter can be inked in after a little practice. You will notice that the slanting lines on the ruled sheet will not always coincide with the letters, but if the slanting lines on the ruled sheet are drawn nearly together, there will be no difficulty in getting the same angle to the letters.

CONNECTIONS FOR A GAS STOVE

UNDER Chips and Spalls, SCIENCE AND INDUSTRY, December, 1899, a subscriber under the *nom de plume* Economist, shows how he connected up a gas stove by placing a meter on a shelf in the kitchen and then asked our readers what they thought of his plan.

In reply to Economist's request we have received so many communications regarding his plan for economizing gas that we cannot

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publish them, but can only give a few extracts from some of them as follows:

"The amount of Economist's gas bill excites my interest and sympathy.

"The only point Economist does not mention and on which the whole question hinges is: Does the gas company read off his new meter at eighty cents and the direct reading of the old one at a dollar and a quarter? If so, our friend had better pay out his three years' saving at once and have the job done right, because all the gas that is registered on the new reading at eighty cents is first registered on the old one at a dollar and a quarter. Economist is in reality paying $1.25 + .80 = $2.05 for every thousand cubic feet of cooking gas he uses, instead of eighty cents, as he imagines. In justice to Economist, the gas company should deduct the difference of the readings of the old meter at a dollar and a quarter and the direct reading of the new meter at eighty cents for his cooking-gas bill. The gas company can be made to refund the amount of their overcharge. That is my opinion, not of his scheme, but of its effects." —R. H. G., Flushing, N. Y.

"Economist should see to it that the reading of the kitchen meter is subtracted from the reading of the house meter, for the gas passes through both meters to get to his stove. He pays for his stove gas twice." —G. H., Suncook, N. H.

"Subtract the quantity metered in the kitchen from the quantity metered in the cellar, and Economist will avoid paying twice for his gas."—L. A. D., Grand Rapids, Mich.

"The company from whom Economist buys his gas would no doubt pay him well to make such connections for all their customers. He is a grand hand at robbing himself. If he makes separate connections with his riser, he will find somewhat of a difference in his bills."—J. M. W., Brooklyn, N. Y.

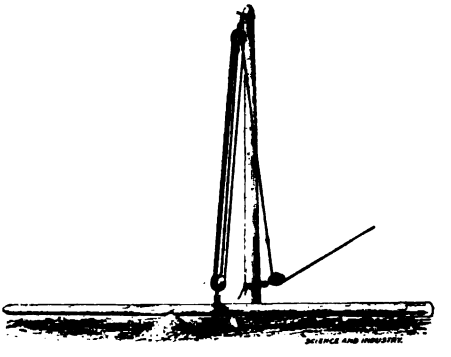
"Economist should get the gas company to make a separate connection from the service, with a ¾-inch pipe to the range, for he certainly does not have a sufficient supply from a ¾-inch pipe to run the oven and top burners at the same time. It is poor economy to run a gas range under $\frac{6}{10}$ of the gas pressure. By running more than two burners at the same time, you reduce the supply at each individual burner. To reduce the light bill and get a more efficient light, he should use Welsbach burners, from which he will get a 60-candlepower light for less than ½ cent per hour; he should also place check burners on fixtures where the Welsbach burner is not used."—A. R. W., Omaha Gas Co.

We have not space to publish any more remarks for Economist's benefit, but we take this opportunity to thank our subscribers for their kind endeavors to show Economist how to save money.

A METHOD FOR RAISING HEAVY POLES.

O. P. Sammons, Rock Island, Ill.

I GIVE below a good scheme that I use successfully on line-construction work for raising poles from 35 to 75 feet in length. With the use of a team of horses, three men can set any size pole with perfect ease and safety. One man is needed to drive the team and one or two near by to guide the pole. The method used will be clear from the cut given. Use a pair of pulleys (two-way) and a snatch block at the bottom of the pole. About 250 feet of ¾-inch rope is necessary, and this is strong enough for raising any ordinary size of pole. The block may be fastened at the top of the old pole



with a sling, and in cases where I have no old pole to hitch to I set up a small 28-foot pole on top of the ground and guy it four ways with ½-inch rope. I use four guy lines 100 feet long. A team and three men will set 25 poles per day where the holes are all dug. A block attached to the pole should be in such a position that the pole will be very nearly balanced when lifted from the ground. After a couple of trials a point will be easily found where the block is so situated that the butt end of the pole will be a little heavier than the other end, so that the pole may be easily guided into the hole. Formerly it required from eight to ten men to set 40-foot poles with pike poles, but this method requires only three men and a team, as described above.

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EDITORIAL COMMENT

PILLEY COMBINATION FLUE BRUSH AND SCRAPER

THE St. Louis Steel Wire Brush Company, 318 North Main Street, St. Louis, Mo., has brought out a new combination flue brush and scraper that in one operation cuts the scale and pushes it out of the flue. These scrapers are made of malleable iron and are carried on four steel arms fastened in the center. They are expanded or contracted by turning the rod to the right or left, thereby moving the slide up or down on the threaded rod in the center. The brush is made of fine round tempered steel wire, the wires passing entirely through the holes in the center, and, being fastened on the inside, make it impossible for them to come out or lay over. The whole is constructed of the best material and designed for hard and rough usage. It will save time and labor, and is thus of value to employer and engineer alike.

GAS ENGINES FOR MINES

THE Weber Gasoline Engine Company, of Kansas City, Mo., after keen competition with the leading gas- and gasoline-engine builders of the United States and Europe, has secured one of the largest single orders ever given for this kind of an engine. These engines, aggregating 450 horsepower, and costing $50,000, are to be built for the Ray copper mines, in Arizona, and are to be operated by No. F. H. distillate, at a cost of 6 cents per horsepower-hour. This order must be installed and in operation by April 1st, and to do this the Weber company must operate its plant day and night. That this corporation stands in the front rank of gasoline-engine builders is also evidenced by the fact that they have received an order for a 30-horsepower engine to be installed at the Norwegian copper mines, Lyngeford Island, on the northern coast of Norway.

DRAWING TABLES

WE HAVE received the latest catalogue of The J. G. Alexander Manufacturing Company, 18 Bowery Street, Grand Rapids, Mich., manufacturers of drawing tables, office furniture, etc. The catalogue contains descriptions and illustrations of the numerous different styles of drawing tables manufactured. With the variety of tables shown, varying from the small school table to the largest table adapted for drafting-room use, no trouble should be experienced in selecting a table adapted to the needs of any one. In addition to drawing tables, filing cases for plans and drawings, work benches, roll-top desks, typewriter desks, and blank cabinets are illustrated and prices quoted.

BOOK NOTICES

THE EMPIRE OF THE SOUTH. Published by The Southern Railway Company.

It has been the aim in the preparation of this volume to present in a frank and forceful manner an unbiased and interestingly written statement of the development of the Southern States in manufacturing, commerce, agriculture, and all lines of human activity. There is not a line of advertising in it, concealed or otherwise, and the volume may well be accorded the credit of being the most comprehensive treatment of southern material interests ever published. The typographical appearance of this volume is very fine indeed, the half-tone illustrations being of a very superior quality. Although the pictures, of which there are over five hundred, are at first sight the most attractive feature of the book, the text is no less interesting and instructive. It is the work of Frank Presbrey, a well-known student of, and writer on, the South. Copies may be had for 15 cents, the exact cost of mailing, by addressing Ch. Hopkins, Division Passenger Agent, 828 Chestnut Street, Philadelphia, Pa.

THE CHOICE OF A COLLEGE FOR A BOY. By Charles Franklin Thwing. Price, 35 cents. New York, T. Y. Crowell & Co.

This little book, by Dr. Thwing, of Western Reserve University, is intended as a guide to the young man that may be contemplating a college course but who has not quite decided on the college he wishes to enter. The book deals with such subjects as location, expense, small versus large colleges, scholarship, and many other interesting questions. We notice one interesting statement to the effect that the proper amount of money for a young man to be supplied with per year in order to do effective work may be obtained by adding together the fee for tuition and the cost of board and room and doubling the result. It would be interesting to know how nearly this approaches the average yearly expenditure of students in our colleges.

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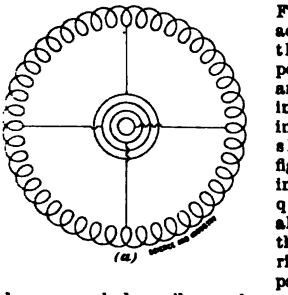
ANSWERS TO INQUIRIES

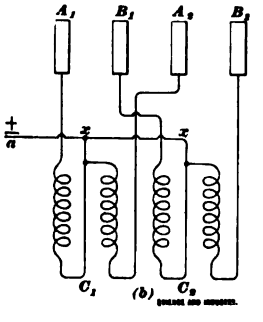
NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

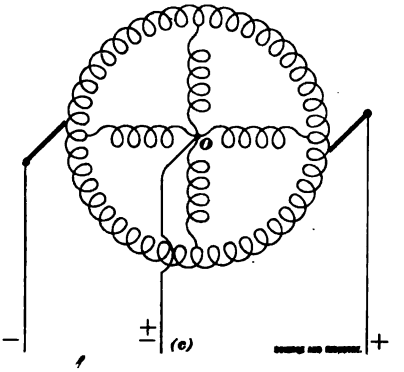
1. *Put this address both on the envelope and at the head of the letter.*
2. *Only questions of general interest to our readers will be answered.*
3. *No questions will be answered by mail.*
4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*
5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*
6. *Reference to inquiries previously answered should give date of issue and number of question.*
7. *Questions cannot be answered in the issue of the month immediately following their receipt.*
8. *Any book not out of print and for sale by regular dealers may be ordered through the magazine.*

[Mr. F. R. Arnold, engineer in charge of the power house of The Boston Terminal Company, Boston, Mass., kindly sends us the following information relating to a machine that is there used for operating lights from one machine on the three-wire system. This is the system referred to in "The Steam-Electric Magazine," September, 1899, Answers to Inquiries, No. 184.—ED.]

The machines in question are connected as follows: From every eighth coil of the regular direct-current winding is led a tap that is connected to a collector ring as shown in Fig. (*a*). On the actual machine there are eight poles, so that there are four taps leading to each ring, instead of one, as shown in the figure. This makes, in reality, a perfect quarter-phase alternator. From the four collector rings the current passes through two balance or choke coils, as shown in Fig. (*b*). Let A_1, A_2, B_1, and B_2 represent the four rings with 90° difference in phase between A and B; C_1 and C_2 represent the choke coils, and wire a is the neutral wire of the system. Now, if we consider C_1 and C_2 as the coils that are wound on a single core with an equal number of turns on either side, we always have at x a potential that is one-half that between the rings A_1 and A_2 or B_1 and B_2, regardless of the position of their respective armature coils, and never more than one-half the potential of the machine. In reality, we have an armature as shown in Fig. (*c*), if we assume that the coils C_1 and C_2 are placed within the armature itself. Thus, the neutral wire is always connected at O, the potential between O and either side of the system being in rapid alternation from O to one-half the voltage of the machine.







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(1) (*a*) Please give rule for figuring out the taper on a piece of work. (*b*) In cutting a taper 1 inch to the foot, how far over do I set the tailstock? (*c*) Does it make any difference if the taper starts a certain distance from the end? (*d*) Is there a standard taper in pipe taps? If there is, please give the diameter of small end. C. W. J., Ravenswood, Ill.

ANS.—(*a*) When a piece of work is to have a taper of, say, 1 inch to 1 foot, this means that the diameter on the big end of the taper is to be larger than that on the small end by $\frac{1}{12}$ inch for each inch of length of the tapered piece; thus, if the piece is 1 inch in diameter at the small end, and if it is 6 inches long, the large diameter will be $\frac{1}{12} \times 6 = \frac{1}{2}$ inch larger, or $1\frac{1}{2}$ inches in all. (*b* and *c*) The tailstock must be set over a distance equal to one-half the taper multiplied by the distance between lathe centers. (*d*) See September, 1899, number of "The Mechanic Arts Magazine," Answers to Inquiries, No. 221.

***

(2) (*a*) Has there not been a company in the Eastern States that has been extracting gold from sea-water? If so, was it done by electrolysis, and, if not, how was it done? (*b*) Can water be decomposed and separated into its elements by a spark from the static machine? (*c*) Can this decomposition be satisfactorily accomplished without adding acid to increase the conductivity of the water? B. F. L., Chicago, Ill.

ANS.—(*a*) A company was formed for extracting gold from sea-water, but it had a very short life. The amount of gold in sea-water is so extremely small that it does not pay to extract it. The method was to extract the gold by electrolysis, so far as we know, but the promoters were very secret as to the methods they used, and the whole scheme was very visionary, to say the least. (*b*) Water may be decomposed by sending a stream of sparks through it from a static machine, or, in other words, sending current from a static machine through it in just the same

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way as from a battery. The volume of current, however, obtained from a static machine, is so extremely small that the amount of water that may be decomposed, by this means, in a reasonable length of time, is so small that this method is never used in practical work. (c) When water is decomposed by using batteries, it is always customary to add acid in order to decrease the resistance, because the electromotive force at hand is fairly low. In the case of a static machine it would hardly be necessary to add acid, because the pressure available is exceedingly high.

***

(3) I have an inflow of 100 gallons of water per minute in a mine, and I want to buy a pump capable of lifting it 1,200 ft.; steam pressure at 80 lb. How shall I figure the size of pump to do the work?

R. E. G., Querida, Colo.

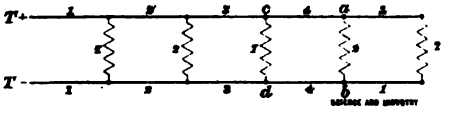
ANS.—Assuming a mean effective steam cylinder pressure of 50 lb., at the foot of the shaft, we calculate the diameters and stroke of a simple single direct-acting pump to discharge 100 gallons of water per minute under a vertical lift of 1,200 ft., as follows: Assume for this lift a piston speed of 80 ft. per minute; then, for water cylinder, $d = 5.585\sqrt{\frac{100}{80}} = 6.188$ in., say $6\frac{3}{16}$ in.; and, for steam cylinder, $d = 4\sqrt{\frac{100 \times 1,200}{50 \times 80}} = 21.909$ in., say 22 in. If we make the length of stroke 24 in. = 2 ft., then $\frac{80}{2}$ = number of strokes per minute. The horsepower of the lift will be found from the formula H. P. $= .00008\,G\,h = .00008 \times 100 \times 1,200 = 45.6$ horsepower.

***

(4) Please show me how to calculate the resistance of the circuit shown in the accompanying figure; that is, what is the resistance from $T+$ to $T-$?

G. W. M., Little Rock, Ark.

ANS.—The resistance of this circuit is easily calculated by applying the law for the resistance of



divided circuits: that is, if you have two circuits A and B in parallel, the resistance of the two combined is $R = \frac{A \times B}{A + B}$. Starting at the right-hand end of the circuit, we have $1 + 2 + 1 = 4$ ohms in parallel with 2 ohms. Hence, we can replace these last four resistances by a single resistance connected between the points a, b, which will be equal to $\frac{4 \times 2}{4 - 2} = 1\frac{1}{3}$ ohms. Now we can combine this $1\frac{1}{3}$ ohms with the two 4-ohm coils, making $9\frac{1}{3}$ ohms in parallel with the 1-ohm coil $c\,d$, and so on until finally we reach the first resistance coil of the circuit. If you follow out this calculation you will find that the total resistance of the circuit will be 2.84 ohms; that is, you have the two first resistances of 1 ohm each and the combination of the resistances beyond the first two is .84 ohm. We have not given the complete solution, as it would take up too much space and it is not a problem of general interest to our readers.

***

(5) What number of wire, either copper or iron, will give best results for long and short distances on telegraph lines?

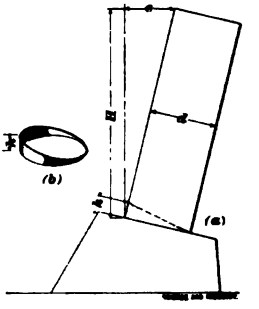
F. W. W., Rockford, Ill.

ANS.—For telegraph lines, experience has shown the following sizes of iron wire to be suitable: For local lines in towns and cities, Nos. 11, 12, and even 14 B. W. G.; between towns and cities not too far apart, No. 8 B. W. G.; between far-distant cities, such as New York and Chicago, No. 4 B. W. G. Copper is superior to iron and is rapidly replacing the latter, especially for long telegraph lines. No. 18 B. W. G. copper is about equivalent to No. 11 B. W. G. iron; No. 15 copper to No. 8 iron; and No. 12 copper to No. 4 iron. However, a smaller hard-drawn copper wire than No. 14 B. & S. gauge is very seldom if ever used for bare overhead line wires.

***

(6) Kindly describe a practical and correct method of straightening an iron stack that has settled to one side, without taking it down, by cutting the bottom sheet; for example, a stack 190 ft. high, 12 in. in diameter, leaning over at the top $7\frac{1}{2}$ inches.

W. D., Harrisburg, Pa.



ANS.—Out of the bottom sheet a wedge-shaped ring must be cut, as shown in the accompanying sketch at (b). The height h of this wedge bears the same proportion to the diameter d of the stack as the lean-over e does to the height H of the stack, or $\frac{h}{d} = \frac{e}{H}$; thus, $h = \frac{d\,e}{H}$. This height h will be very small generally: in your example, for instance, it will be $h = \frac{12 \times 7\frac{1}{2}}{190 \times 12} = .04$ in. only. An incision with a saw would do the business in this case. After cutting, a patch must be put on.

***

(7) (a) Is there any method, other than the weir, by which the flow of an Artesian well can be measured? (b) Could the flow be measured by means of the pressure in the pipe?

D. H. J., San Bernardina, Cal.

ANS.—(a) If the flow from the well is small, it might be measured by allowing it to fill one or more tanks of known capacity and observing the time required. (b) The flow could be estimated by forcing the discharge to take place through a nozzle, and measuring the pressure in the pipe just back of the nozzle. If p = pressure in the pipe at the nozzle in lb. per sq. in., and d = diameter of the nozzle in inches, the quantity of water discharged by the nozzle in cu. ft. per sec. is given approximately by the formula $Q = .065\,d^2\sqrt{p}$. This formula assumes that the nozzle is of such a form that the actual discharge is .98 of the theoretical discharge. Any attempt to measure the flow by means of a nozzle would probably reduce the flow, since it would have the effect of increasing the back pressure or head against which discharge would take place.

***

(8) We have a 150 H. P. Corliss engine, developing at present 80 H. P. We use the exhaust steam for heating water for the boilers and the factory. The steam passes through two heaters and then into the air. But, as only part of the exhaust steam is used in the heaters, I propose to put a back-pressure valve on the exhaust pipe, set the valve to 5 lb., and use the steam to heat the water in the kettles used for sizing hats. At certain times of the day there is not enough exhaust steam, and for that reason we propose to connect a live-steam pipe to the kettles, with an

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automatic valve to give a continuous flow of steam to the kettles. Our boiler pressure is 75 lb. Will the proposed change reduce the coal consumption? Will we have to increase the boiler pressure to get the same work from the engine?
M. D. M., New Milford, Conn.

ANS.—Your engine being badly underloaded, an increase in the back pressure will cause a later cut-off, it being an automatic cut-off engine. This will cause slightly better economy. The proposed change will probably reduce the coal consumption slightly; whether the saving effected will be sufficient to warrant the expense of the changes we cannot tell without a personal examination. It is not necessary to increase the boiler pressure.

***

(9) What can I use to separate iron from old brass and copper, and copper from lead and tin, in melting them? J. A. M., Philadelphia, Pa.

ANS.—Iron cannot be separated from old brass and copper during melting. Previous to melting, a very good separation can be made by a magnetic separator, which will remove the iron from brass chips. In case the chips contain grease, it will be necessary to wash them with hot soda water first and then treat them with the magnetic separator. Copper cannot be separated from lead and tin during melting in any practical manner, nor can a compound containing zinc be separated successfully. If an alloy contains these deleterious elements, it will have to be used in the manufacture of some other alloy in which they are not objectionable and in which they can be diluted by new metal to such an extent as to do no damage.

***

(10) What kind of a machine is used to make the eyes in miners' picks? D. M. H., Peru, Ill.

ANS.—The best machines for forging pick eyes are known as forging presses, and are manufactured by Beaudry Hammer Co., Boston, Mass., and The E. W. Bliss Co., 17 Adams Street, Brooklyn, N. Y.

***

(11) (*a*) Where can I get a brace that will hold the bit when being pulled out? (*b*) What is the meaning of the following words taken from Psalm 119: Aleph, Beth, Van, Zain, Cheth, Yeth, Jod, Caph, Lamed, Hem, Nun, Samech, Ani, Pe, Yzaddi, Koph, Resh, Schin, Yan? A. P. A., Gold Hill, Ala.

ANS.—(*a*) Consult the advertising columns of this publication, or send to Montgomery Tool Co., Fulton Street, N. Y. (*b*) The words heading each division of Psalm 119 are the names of the Hebrew alphabet characters in their order, and are represented in our alphabet by the following letters: A, B, G, D, H, U, Z, C, TH, Y, K, L, M, S, A (quiescent), P, Ts, Q, R, S, T.

***

(12) Can you recommend a good book on horseshoeing? A. C. A., Freedom Plains, N. Y.

ANS.—We cannot find any book on this subject in the catalogues here on file. Perhaps one of our readers may know of one.

***

(13) Which is the more economical way of running belts—flesh or skin side next to pulley?
D. S., Dolgeville, N. Y.

ANS.—This question is by no means definitely decided, and probably never will be, since there are two things to be considered: greatest adhesion and greatest durability. Running the flesh side next to pulley gives greater adhesion, especially with new belts and new metal pulleys. In the case of old belts and old pulleys it is usually found that the grain side drives better. For durability, the grain side should be run next to the pulley, as the fibers next to the flesh side are stronger by a considerable amount than the grain-side fibers, and it is the outside fibers that have to withstand the greatest stress, especially when pulleys are small. The International Correspondence Schools, in accord with many practical engineers, recommend running the grain side next to the pulley, and we believe this to be the prevailing practice in this country. European engineers, especially on the continent, almost invariably run the flesh side next to the pulley.

***

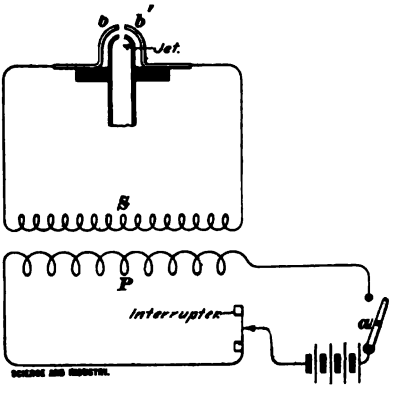
(14) Is there any method of taking copies of printed matter from magazines by letterpress, or by any other method? H. H. E., Waynesboro, Pa.

ANS.—No.

***

(15) Please tell me through your columns (*a*) the best method for lighting gas with an induction coil; (*b*) some form of rigging to be used to light a gas stove. G. J. H., Milwaukee, Wis.

ANS.—(*a*) The ordinary arrangement for lighting a gas jet with an induction coil is shown in the figure. *P* is the primary of the induction coil and *S* the secondary; *b* and *b'* are two tips attached to the jet by insulating material. These two tips are connected to the secondary of the induction coil. When the switch *a* is closed a spark jumps between the gaps, thus lighting the gas. (*b*) We do not know the style of burner to which you wish to attach this



igniter, but from the above diagram you should be able to rig up a pair of electrodes *b*, *b'* at some point on the burner where they can be easily connected. You must see that these electrodes are very thoroughly insulated by some such insulating material as asbestos or mica, that will stand considerable heat; also, the wires leading from the secondary to the igniter must be thoroughly insulated. For work of this kind it would probably be more satisfactory to arrange an igniter using an ordinary spark coil with some kind of wiping contact at the burner instead of an induction coil, because you will find it a difficult matter to keep the induction-coil outfit in good working order. This latter method is the one generally employed in ordinary gas-lighting work.

***

(16) Will you give me some test to distinguish between first-class anthracite coal and the inferior grades of the same? W. L. L., Ottawa.

ANS.—The quality of coal may be determined by the ash test, which is made by burning a weighed portion of the coal in a small porcelain crucible. The heating can be accomplished over a gas burner or alcohol lamp. The material should be kept at a red heat with free access of air until only a red or

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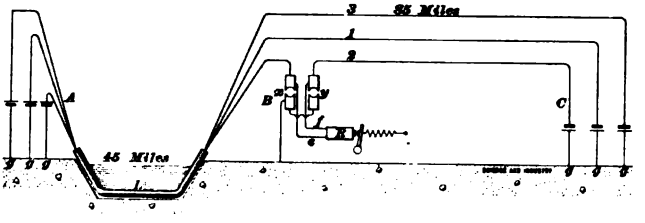
gray ash remains. This ash should then be weighed and the percentage, as compared with the coal, calculated. A good anthracite should not contain more than 10% ash, but it will occasionally run as high as 14% or 15%. A good anthracite should be glossy in appearance and should break with a conchoidal fracture. When it has slaty streaks running through it, it is apt to run high in ash and is generally of a poor quality. Almost any druggist has the necessary apparatus for making an ash test.

***

(17) In the accompanying diagram, *L* is a three-core cable 45 miles long. No. 3 wire is duplexed; No. 1 wire has two offices cut in besides *A* and *C*; No. 2 has about twenty offices cut in besides *A*, *B*, and *C*. I am located at *B*, the last office before the line enters the cable on this side. The distance from *B* to *C* is 85 miles. One day the key of No. 2 was open at *A*, and, happening to insert my ground plug at *y* I found that my relay gave a click the instant the plug made contact. The current was only



momentary but was quite strong, for, by pulling my relay spring to full tension, it would not hold the lever, and on connecting a 4-ohm sounder to the wires *e* and *f* the sounder gave the same click. Please give the probable reason of the current causing the click, and also the reason it was so strong. R. W. T. B., Departure Bay, B. C.

ANS.—Without more definite information and data a definite reply can hardly be given to your question. However, the following explanations are offered: If the key on line No. 2 at office *A* is *open*, and line No. 2 is neither grounded nor crossed with either line No. 3 or No. 1, then a momentary current is probably due to a very large electrostatic capacity between line No. 2 and either line No. 3 or No. 1 in the 45 miles of cable. A very bad leak or a cross between offices *A* and *B* and between line No. 2 and either line No. 3 or line No. 1 might possibly account for the heavy current mentioned. The large current would be due to the large electrostatic capacity in the cable or to the high voltage used on line No. 1 or No. 3, or to both.

***

(18) (*a*) Where can I get a table containing the numerical values of sines, cosines, tangents, and cotangents of angles? (*b*) Also a table of hyperbolic sines, hyperbolic cosines, hyperbolic tangents, and hyperbolic cotangents? Can you supply them, and what is the price? (*c*) What is the .4th power, the .6th power, the 1.6th power, and the 5.8th power of a number? (*d*) What is the price of the latest edition of W. C. Ayrton's book "Practical Electricity"?
J. B., Central Falls, R. I.

ANS.—(*a*) The "Mechanics' Pocket Memoranda" contains a convenient four-place table of sines, cosines, tangents, and cotangents of angles. It can be obtained from The Technical Supply Co., Scranton, Pa.; price, $1.50. For calculations requiring greater accuracy than is attainable with four-place tables, the best tables are "Vega's Logarithmic and Trigonometrical Tables," which can be had from The Technical Supply Co.; price, $2.50. (*b*) A table of hyperbolic functions is given in *Des Ingenieurs Taschenbuch*. The Technical Supply Co. can obtain this book for you, but it would require some time, as the book would have to be imported from Germany.

(*c*) If m and n are integers, $a^{\frac{m}{n}}$ means the nth root of the mth power of a; thus, $a^{\frac{m}{n}} = \sqrt[n]{a^m}$; $a^{\frac{4}{10}} = a^{\frac{2}{5}} = \sqrt[5]{a^2}$; $a^{.6} = \sqrt[5]{a^3}$; $a^{1.6} = a \times a^{.6} = a \times \sqrt[5]{a^3}$; $a^{5.8} = a^5 \times a^{.8} = a^5 \times \sqrt[5]{a^4}$. (*d*) The price of Ayrton's "Practical Electricity" is $2.50. It may be obtained from The Technical Supply Co., Scranton, Pa.

***

(19) (*a*) Please give a formula for the safe pressure on cylinders when the pressure is applied externally. (*b*) How much external pressure would a cylinder made of hemlock 1 in. thick safely carry, the length of the cylinder being 15 ft. and its diameter 14 ft.? A. M., Port Morieu, N. S.

ANS.—(*a*) For a perfect cylinder subjected to a uniform external pressure, the formula for the safe working pressure in lb. per sq. in. is $p = \frac{2tS}{d}$, in which t = thickness of cylinder walls in inches; d = diameter of cylinder in inches; and S = safe compressive strength in lb. per sq. in. of the material of which the cylinder is made. Since it is difficult to make a perfect cylinder, this formula cannot be relied on; any change from the cylindrical form weakens the cylinder, and makes it liable to fail by collapsing under a pressure less than that given by the above theoretical formula. It is difficult to construct a perfect cylinder or to keep the cylindrical form when under pressure, and, since the amount of weakening varies with the amount of variation from the circular form, it is difficult to calculate the external pressure that a cylinder of given dimensions will stand. (*b*) Unless stiffened by flanges, heads, or braces, such a cylinder would not stand a very heavy pressure. Just how much it could be made to carry is hard to calculate.

***

(20) (*a*) What is the economical effect of cushion valves in the steam ports of pumping engines? (*b*) Please explain their use. W. A. M., Victor, Colo.

ANS.—(*a*) Cushion valves are used to regulate the amount of compression so as to secure a constant stroke of the pump plunger. By so adjusting the valves that the maximum stroke of the pistons that is possible without striking the heads is obtained, the losses from clearance in the steam cylinders are reduced to a minimum. (*b*) The use of the cushion valves was fully explained in "The Mechanic Arts Magazine," February, 1899, Answers to Inquiries, No. 9.

***

(21) Does it require less energy for a man to ride a certain distance, say half a mile, on a modern ball-bearing bicycle than for the same man to walk or run the same distance in the same time? The man to weigh 150 lb., the bicycle 20 lb.; the road to be perfectly level, hard, and smooth; the man when walking will lift his body, say, 2 in. at every step.
P. N., Allentown, Pa.

ANS.—According to the best authorities, it takes less energy to ride a certain distance on a bicycle than to walk or run the same distance. Taking the data given by you, let us assume that the man runs a mile, making a step of 3 feet. The work done per step in lifting the body 2 in. would be $150 \times \frac{2}{12}$ = 25 ft.-lb. The work done in a mile would be

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$25 \times {}^{8}\!/_{12}{}^{2} = 44{,}000$ ft.-lb. A certain amount of work is also expended in overcoming the resistance of the atmosphere. When a man is on a bicycle, his body as a whole is at practically the same distance from the ground all the time. The lower limbs only are moved up and down. Let the weight of the limbs be 40 pounds and suppose the bicycle to be geared to 84. There will then be one complete turn of the cranks for every 22 ft. travel of the wheel. In a mile there will be ${}^{5280}\!/_{22} = 240$ turns. If the cranks are 6 inches long the work in lifting the limbs will be $40 \times 1 \times 240 = 9{,}600$ ft.-lb. To this must also be added the work necessary to overcome the resistance due to friction between tires and ground and that due to friction of the mechanism of the wheel. The above determinations must not be considered as exact results, because the various assumptions made may not be exact. However, the experiments that have been made, to determine as nearly exact results as could be made, indicate that much less energy is expended riding a good bicycle than on foot.

***

(22) Can you tell me how to find the weight necessary to hold down a cubic foot of timber, say fir, under 20 ft. of fresh water at an elevation of 1,700 ft. above sea level?

J. C. B., Kuskowook, Idaho.

ANS.—The upward pressure of water on an immersed body is equal to the weight of the water displaced by the body; therefore, the weight required to hold down a cubic foot of timber is equal to the difference between the weight of a cubic foot of water and the weight of a cubic foot of timber. Since water is almost incompressible, the depth to which the block is immersed and the elevation above sea level have practically no effect on the weight required to hold the wood down.

***

(23) (*a*) What is the resistance per foot of No. 26 B. & S. German-silver wire? (*b*) How is the ordinary permanent horseshoe magnet charged? (*c*) How may a small current of electricity be made to decompose water? (*d*) What size storage battery would be required to supply current to one 6 c. p. 10-volt lamp for 3 hr.?

F. F. B., Palermo, Cal.

ANS.—(*a*) The resistance of German-silver wire varies considerably with the materials used. The resistance of No. 26 B. & S. wire with 18% nickel is about 748 ohms per 1,000 ft. For wire with 30% nickel, the resistance per 1,000 ft. would be 1,163 ohms. (*b*) An ordinary horseshoe magnet may be magnetized by winding a coil of insulated wire around it, as shown in Fig. 1. It is also well to place a piece of iron across the poles, though this is not absolutely necessary. Use any size of insulated wire that may be convenient, and wind on as many turns as you have room for. Send as strong a current through the wire as it will stand without overheating. You can also magnetize a horseshoe by bringing its poles in contact with the poles of a dynamo, but the above method is generally more satisfactory. (*c*) You can make a simple apparatus for decomposing water as shown in Fig. 2. Take a funnel and insert a cork in the stem; pass through the cork two stout wires *t*, *t'*, and fasten to the ends of these wires two small pieces of platinum foil *c*, *c'*. Fill the funnel nearly full of acidulated water, and invert two test tubes *d*, *d* full of water over the plates. These test tubes may be held in place in holes bored through a wooden strip *k*. The wires *t*, *t'* should be covered with an insulating varnish up to the point where the platinum plates are attached. Two or three goods cells of

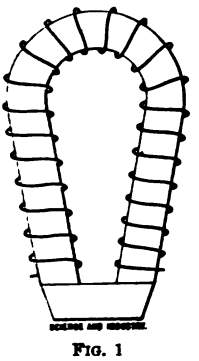

FIG. 1

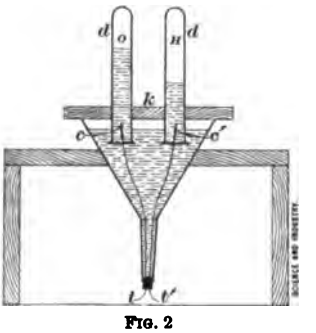

FIG. 2

battery should be sufficient. (*d*) A 6 c. p. 10-volt lamp will require about 2.4 amperes. A 10-ampere-hour battery would, therefore, be quite large enough for the purpose. You would need 5 cells connected in series to get 10 volts.

***

(24) I wish to wind pipe around the columns from floor to ceiling in a building where I am working. The ceiling is 15 ft. high, and I wish to make ten coils in that distance. The pipe is $1\frac{1}{4}$ in. in diameter. How can I figure the exact length of pipe necessary?

H. S., Anaconda, Mont.

ANS.—The curve assumed by the pipe will be a helix, and will be the same as the curve formed by the hypotenuse *a b* of a paper triangle when wrapped around a cylinder, as shown in Fig. 1. The height that the pipe will rise in one turn is equal to one-tenth of 15 ft., or 18 in., corresponding to *a c* in Fig. 1. The diameter of the coil, measuring to the center line of the pipe, is equal to 18 in. + $1\frac{1}{4}$ in., or $19\frac{1}{4}$ in. The distance around the column, then, corresponding to *b c* in Fig. 1, is $3.1416 \times 19\frac{1}{4} = 60.48$ in. Then the length of pipe

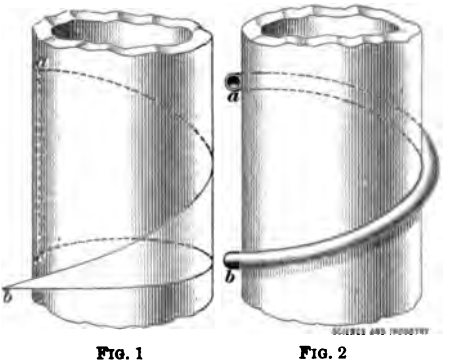

FIG. 1 FIG. 2

necessary to make one turn, as shown in Fig. 2, will be the hypotenuse of a triangle of which the height is 18 in. and the base 60.48 in. This length is found to be $\sqrt{60.48^2 - 18^2} = 63.10$ in. The length for ten turns would then be $10 \times 63.10 = 630$ in., or 52.5 ft. The above solution is embodied in the formula $l = n\sqrt{\pi^2 d^2 + t^2}$, where l = the length of

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the pipe; $\pi = 3.1416$; d = diameter of the coil; t = pitch, or the rise on one turn; n = number of turns.

***

(25) Solve the following two problems without using algebra: (*a*) What are the dimensions of a vessel to hold 1 gal. (231 cu. in.), whose height is 1½ times its lower diameter and whose upper diameter is ⅔ as large as the lower? (*b*) of a cylinder whose height is equal to the diameter?

J. E., Quincy, Ill.

ANS.—(*a*) Assume the lower diameter to be 12 in.; then upper diameter is $12 \times \frac{2}{3} = 8$ in., and height is $12 \times 1\frac{1}{2} = 18$ in. The volume of this frustum of a cone is 1,432.57 cu. in., nearly. Applying the principle that the volumes of similar solids are to each other as the cubes of any line similarly placed in each, $1,432.57 : 231 = 12^3 : x^3$, whence $x = 6.53$ in. = diameter of lower base. Diameter of upper base $= 6.53 \times \frac{2}{3} = 4.35$ in., and height $= 6.53 \times 1\frac{1}{2} = 9.8$. (*b*) Assuming diameter and height to be 12 in., volume of cylinder is 1,357.17 cu. in. Applying same principle used above, $1,357.17 : 231 = 12^3 : x^3$, whence $x = 6.65$ in. = diameter and height of cylinder.

***

(26) What is the best non-inflammable to place in a pail of water to prevent freezing?

ANS.—Use plenty of salt in the water.

***

(27) (*a*) Will a dynamo produce light if enclosed in an air-tight glass case (air exhausted)? (*b*) Would it give light if enclosed in an air-tight case (air not exhausted), and if so, for how long? (*c*) Could it be possible for an electric current to return at a potential, or pressure, less than that of the earth, or zero?

W. W. R., Brockton, Mass.

ANS.—(*a* and *b*) Your questions seem to indicate that you think a dynamo requires air in order to generate. A dynamo does not generate electricity by utilizing the oxygen of the air, and therefore it would generate as well in a vacuum as in the air. The electricity is generated by the conversion of the mechanical energy supplied into electrical energy. (*c*) Electricity will flow between two points so long as the potential of one point is higher than that of the other, and it makes no difference what the absolute potential is with regard to the earth. If one point were, for instance, at a potential of —100 and another at —200, the first point would be at a higher potential than the second, and current would flow from the first to the second, although the absolute potential of both is less than that of the earth.

***

(28) (*a*) What is the cause of a grating noise heard in the cylinder of a hoisting engine after running for some time at high speed and under full load? The piston has one packing ring, and the cylinder is kept well lubricated. (*b*) My air-brake lubricator feeds for a short time and then stops; if I let out some of the oil and water it will start feeding again but will stop after a short time. Why is this, and how can it be made to feed continuously? (*c*) How can I melt brass for making models and small castings?

R. R. H., Tacoma, Wash.

ANS.—(*a*) The cause is undoubtedly that the cylinder is dry, although you think it is well lubricated. (*b*) The trouble is due to the lubricator getting chilled—a common complaint in winter time but not in summer, unless the lubricator has a cold draft playing on it. This chilling effect stops the circulation. By letting some of the oil and water out, the steam will enter and start up the circulation again. If you could locate the lubricator in a warm place, your trouble would vanish. (*c*) The melting point depends on the composition—say about 1,850° F. as an average. You might melt the brass in a crucible on a common fire if you had good coal and a strong draft. Have a cap or cover over the crucible, and sink the latter into the body of the fire; that is, pile the fire well up around it and keep up a good draft.

***

(29) When connecting a pipe to a boiler having a bumped head, should it be connected to the center of the head, or can it be placed at any other point without lessening the strength of the head?

A. S. H., Glastonbury, Conn.

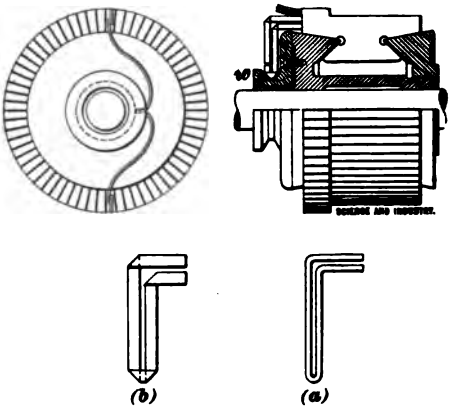
ANS.—There is no doubt that the central position is the best, the stresses in the head being more evenly distributed. There is, however, no danger in placing the pipe at any other point, as there is a considerable margin of strength to make up for the irregularity of stress due to an eccentric connection.

***

(30) (*a*) Will you inform me how a commutator of a 4-pole compound shunt dynamo is cross-connected, illustrated by a simple sketch? (*b*) What is the advantage of this construction?

R. C., East Port, Md.

ANS.—(*a*) The commutator of a 4-pole dynamo is usually cross-connected either by means of copper strips or copper wires. The former are used when the current to be carried is considerable. The best method of cross-connecting is to arrange the connectors in two layers in the form of involutes, as



shown in the figure. These connectors may be a single loop made of copper wire, as shown at (*a*), or may be made up of copper strips folded, as shown at (*b*). The cross-connectors may be supported by a turned wooden piece *w*, as shown. (*b*) By using a cross-connected commutator, machines that would otherwise require four brushes for their operation may be run with two brushes. It is generally advisable, however, to use windings that will not require a cross-connected commutator, as these cross-connections render the construction more complicated.

***

(31) (*a*) A certain boiler is to take its feedwater from a tank alongside, the water to be fed by injector at about 85° F. Which method of heating the feed would you advise: (1) live steam, turned direct into the tank from the boiler; (2) exhaust steam, turned direct into the tank; or (3) exhaust steam, running through a pipe coil in tank and exhausting thence into the atmosphere? I am afraid that (2) may give trouble through priming, as I use half a pint of cylinder oil every 7 or 8 hours. (*b*) What causes a slide-valve engine to tremble, both when working at full and at half load? (*c*) What effect will too much lead have on an engine? E. W. B., Rock Island, Que.

ANS.—(*a*) Use method (3). This is more economical than (1) and is also better than (2), inasmuch as

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the back pressure will then be less. It will also avoid any trouble due to oil in the feedwater, although a moderate amount of mineral oil is rather advantageous than otherwise with certain waters. (*b*) The trembling may be due to many causes; such as bad balance; engine loose on its foundation, or the foundation itself imperfect; too much or too little lead; no piston clearance; loose piston or crosshead; knock in guides, connecting-rod, or bearings; crank-shaft out of square with with guides; water in cylinders; crosshead actuating a pump that is badly cushioned. (*c*) It will decrease the efficiency of the engine, and will affect the smooth running and heat up the pins.

***

(32) I am running a traction engine, carrying 150 pounds pressure. I find that, when the boiler is cold, the reverse lever will not drop down low enough for the catch to enter the last notch; in fact, it falls ½ inch short of it; when the lever is pushed up the catch comes that amount short of the notch at the other end. As you will see from the sketch, the chord of the reverse sector makes an angle of about 60° with the reach rod. Can you explain the above?

J. F. M., Neche, N. D.

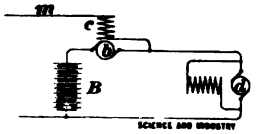
ANS.—According to your sketch, if the reach rod were to be lengthened, the reverse lever would drop farther down the sector than it now does, and would not push up so near the top. When the boiler cools down, the effect is the same as if the reach rod had been lengthened—other lengths remaining the same. So if, when steam is up, the reverse-lever catch enters both end notches in turn, we see that when the boiler is cold the catch will fall short of the lower end notch and overtravel the top one. This result is the exact opposite of what you state to be the case, but is what your very meager sketch leads to.

***

(33) (*a*) I have a battery of three steam boilers connected to one drum. From one end of the drum a steam pipe leads to two engines. Can you explain why water is drawn along with the steam from the boiler farthest away from the steam-pipe end of the steam drum when all three boilers are working together, supplying steam to the drum? (*b*) What is a "booster," why is it put in a circuit, and how is it connected up?

J. E. C., Baltimore, Md.

ANS.—(*a*) Your question is not quite clear. Do you mean that the boiler is foaming, or do you mean that it is priming badly? In either case it would take a personal examination before we could venture an opinion. (*b*) A "booster" is a low-voltage dynamo generally used in connection with a storage battery for the purpose of regulating the charge and discharge of the latter. In the figure, let *d* represent an ordinary shunt dynamo supplying current to the lighting mains. The field *c* of a low-voltage dynamo, or booster *b*, is connected in series with one of the mains of the shunt dynamo *d*. The armature of the booster is connected in series with the storage battery *B* across the mains. The E. M. F. of the dynamo is a little greater than that of the battery, so that it will charge the battery when there is no external load. When all the lights are turned on the booster field will be fully energized, and the E. M. F. of the booster will be added to that of the battery, thereby causing the battery to discharge and assist the dynamo. At medium load, the battery will be neutral, neither taking current nor discharging it, while the dynamo is running at full load. Any increase in load is then taken by the battery.



(34) If a boat is run by a motor operated by a set of storage batteries, could the boat be run while a generator is charging another set of storage cells?

W. W. G., Brockport, N. Y.

ANS.—No; you would only be taking power out of one battery and putting it into another, and, what is more, you would lose a large percentage of power in so doing. You cannot expect to use the power for running the boat and at the same time have enough to charge another battery. This would be a very desirable thing, were it possible, but, like the perpetual-motion machine, it cannot be made to work.

***

(35) How can I build a jug neck to a cistern that is to be kept below the ground far enough to avoid freezing?

V. L. F., Port Ewen, N. Y.

ANS.—There are several ways to do it. One is to shape the inside form of the jug neck in damp earth or sand and build to or on it, in the same manner a wooden center is used in building masonry arches; after the work is set, the earth can be excavated from the inside of the cistern. Another way is to make a scale drawing of the cistern neck, and, working to the drawing, corbel out each course of brick the required amount.

***

(36) (*a*) What can I use for the pump valve of a gasoline hand torch? Leather does not hold tight enough, and common rubber generally dissolves quickly. (*b*) Why does The White Manufacturing Co.'s torch flare, hiss, and blow out?

W. R. F., Syracuse, N. Y.

ANS.—(*a*) Pure, soft, gum rubber is generally used for these valves, and it gives good satisfaction. If you use leather, we would suggest that you soak it in melted mutton tallow. This will close the pores of the leather without hardening it. (*b*) The most likely cause is that the burner is not heated enough before the gasoline is lighted. The principles of construction of gasoline burners are so well known to manufacturers that we do not think the trouble lies in the burner.

***

(37) What are the linear and cubical expansions (*a*) of glass? (*b*) of platinum? (*c*) Is there any theory to account for the performance of the gyroscope? (*d*) Why does the ring enclosing the wheel revolve in the opposite direction to that of the wheel when the top is suspended or placed on a pedestal?

J. W. D., McKeesport, Pa.

ANS.—(*a*) Glass will expand about $\frac{1}{1000}$ in length when heated from 32° F. to 212° F. Under the same condition its cubical expansion will be $\frac{1}{333333333}$. (*b*) Platinum under the above conditions will expand in length $\frac{1}{1100}$; and in volume $\frac{1}{333333333}$. (*c* and *d*) Any satisfactory explanation of the gyroscope would occupy more space than we can afford in these columns. The theory is very difficult, but a popular explanation will be found in our March issue in the article "A Great Discovery," where this question is discussed in connection with the precession of the equinoxes.

***

(38) (*a*) How many and what size of plates should be used to make a 50-ampere-hour storage battery that may be easily handled? (*b*) How far apart should the plates be, and of what material should the insulation be composed? (*c*) Does it make any difference whether the plates are close together in a storage battery or not? (*d*) What should be the resistance of the above size?

A. J. W., South Superior, Wis.

ANS.—(*a*) Allowing a discharge rate of about 7 amperes, you would need about 7 plates (3 positive, 4 negative) each having about 33 sq. in. area on each side; i. e., the plates should be about 6 in. × 5½ in., or you might make them 6 in. × 6 in. and have some margin for overloads. If you wish the battery to be

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easily handled, it should be mounted in rubber cells and sealed up in some way to prevent the liquid from spilling. (*b* and *c*) The plates should be placed as close together as practicable without danger of their becoming short-circuited. The closer they are, the lower will be the resistance of the cell. The plates are usually not less than $\frac{1}{16}$ or $\frac{1}{8}$ in. apart, and hard rubber or glass rods are used for insulation. The former are preferable, as they are not so likely to break. (*d*) The resistance of such a cell would probably be in the neighborhood of .02 ohm, but this resistance would depend largely on the distance between the plates.

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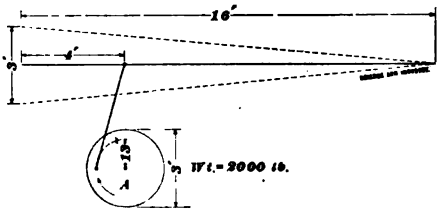
(39) (*a*) With the arrangement of wheel, connecting-rod, and lever shown in the sketch, how much power will be required to raise a weight of 800 lb. at the end of the lever through a height of 3 ft.



60 times per minute, no work being done on the down stroke? (*b*) How great a weight can be raised by the arrangement shown? The gain from momentum is what I especially want to know.

H. E. J., Downey, Cal.

ANS.—Before answering your question we would call your attention to an error in your sketch. In order that the motion of the end of the lever may be 3 ft. with the proportions you give, the crank must have a radius of 18¾ in., instead of 18 in., as shown by your sketch. (*a*) The theoretical power required to raise a weight of 800 lb. to a height of 3 ft. 60 times in 1 min. is $\frac{800 \times 3 \times 60}{33{,}000} = 4.36$ H. P., nearly. No arrangement of wheels and levers could possibly be made to do the work with the expenditure of less than the theoretical amount of power. In general, the actual power required will be considerably more than the theoretical. (*b*) The weight that can be raised depends on the amount of power available, and on the percentage of this power that must be used in overcoming the losses produced by friction and shock. The flywheel has the effect of reducing the losses that would be produced by shock and by the inequality in the driving force required at different parts of the stroke. Just how much saving there will be in your case is difficult to calculate. It depends on the nature of the driving force and the work to be done—conditions not stated in your question. However, the wheel is so small in proportion to its velocity of rotation and the quantity of work to be done that the gain from its use will be comparatively small. Its effectiveness would be greatly increased by gearing it to the crank-shaft in such a manner as to give it a higher rotative speed.

***

(40) Please inform me whether a metallic piston-rod packing is made for use on the ammonia cylinder of an ice machine.

H. T. S., Boardman, N. C.

ANS.—Yes. For information write to the following: The Garlock Packing Co., 12 Pearl St., Boston, Mass.; Knowlton Packing and Supply Co., 19 Pearl St., Boston, Mass.; F. W. Bradley, 206 Equitable Building, Boston, Mass.; A. W. Chesterton & Co., 49 India St., Boston, Mass.; The Hoyt Metal Co., St. Louis, Mo.; John M. Watt's Sons, 136 Liberty St., New York, N. Y.; The United States Metallic Packing Co., Thirteenth and Willow Sts., Philadelphia, Pa.; Phenix Metallic Packing Co., 177 La Salle St., Chicago, Ill.; Swain Lubricator Co., 250 Lake St., Chicago, Ill.

***

(41) (*a*) Please explain the principle upon which horsepower is calculated. (*b*) Give method for drawing a true ellipse, and also several approximate methods for drawing the same. (*c*) How would you find the value of x in the expression $x^6 = 46{,}656$? (*d*) In your answer to Question 161 (*b*), August, 1899, number of "The Mechanic Arts Magazine," I do not understand why you multiply $\frac{100^2}{2} + \frac{100^2}{3 \times 100}$ by 3.1416.

J. S. T., Hampton, Va.

ANS.—(*a*) Horsepower is always computed by multiplying the resistance overcome expressed in pounds by the distance in feet through which this resistance is overcome in 1 minute, and dividing by 33,000. This is the principle used, and all formulas giving the horsepower of a machine or of any moving body overcoming a resistance are based on this principle. (*b*) All books on drawing give methods for drawing true ellipses, and also curves that approximate to the ellipse. (*c*) We should find the value of x by extracting the sixth root of 46,656, using logarithms. If you do not know how to use logarithms, you can find the value of x by extracting first the square root and then the cube root. (*d*) It would require too much space to explain how this expression is derived. It was for this reason that the derivation was not given in the answer to the original question.

***

(42) (*a*) How many board feet in a piece of timber 10″ × 10″ at the base, 5″ × 8″ at the top, and 25 ft. long? (*b*) A board is 1 in. thick, 5 ft. long, 17 in. wide at one end and 7 in. wide at the other; how far from the small end must it be cut straight across so that both pieces will weigh the same?

J. W. U., Uriah, Cal.

ANS.—(*a*) In practice, the number of board feet would be computed as if the timber were 25 ft. long and 10″ × 10″ throughout, and the number of feet would consequently be equal to $\frac{10 \times 10}{12} \times 25 = 208\frac{1}{3}$ ft.

(*b*) Applying the formula,

$$l = \frac{c}{2(a-b)}\left[\sqrt{2(a^2+b^2)} - 2b\right],$$

in which c is the length of the board on a line perpendicular to the base, a is the width at the large end, b is the width at the small end, and l is the distance from the small end to the place of cutting. In the present case we have

$$l = \frac{25}{2(17-7)}\left[\sqrt{2(17^2+7^2)} - 2 \times 7\right] = 15 \text{ ft.}$$

***

(43) (*a*) Will you kindly tell me the best and quickest way to reverse the polarity of a No. 8 Brush arc dynamo and also an M. D., T. H. dynamo? (*b*) Can you tell me why a T. H. dynamo can carry a heavier load with thin segments than with thick ones? (*c*) I have two T. H. machines that I run in series and the current varies from 8 to 10 amperes; is it possible to steady it? T. J. A., Boston, Mass.

ANS.—(*a*) If you cannot readily send current through the machine from some other dynamo, the simplest way is to reverse the connections at the switchboard in order to make the lamps burn properly. If you can readily obtain current from another machine, short-circuit the armature of the reversed dynamo by means of a loop connected across the armature terminals, then send current through from the other dynamo, seeing that the positive terminal of one machine is connected to the negative terminal of the other. The above had better be done

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with the armature of the faulty machine standing still. (*b*) If everything is properly adjusted, the machine should work as well with thick segments as with thin ones. It may be that your regulator is in such condition that it works better when the arc of the segments is shortened by their wearing down. (*c*) You should be able to make the current regulate better than this. Examine the wall controller carefully and see whether it is working right. By adjusting the tension on the spring of the wall controller you may be able to improve the regulation considerably.

***

(44) Is the following the correct formula for finding the quantity of steam in cubic feet that will be delivered through a ¼-inch round hole at a pressure of 90 lb. per sq. in. above the atmospheric pressure? Area of hole = $\frac{(\frac{1}{4})^2 \times .7854}{144}$ = .000085 sq.ft. Velocity of steam at 90 lb. = $\frac{90 \times 144}{.044} \times 8 \times .62$ = 2,380 ft. per sec.; or, 2,380 × 60 = 142,800 ft. per min. The number of cubic feet per minute, therefore, is equal to .000085 × 142,800 = 12. In the Babcock & Wilcox catalogue it is stated that steam travels at a constant rate of 888 ft. per sec. when flowing into a medium having less than ½ the initial pressure.

W. D., Pittston, Pa.

ANS.—We do not recollect of ever having seen the formula for the velocity which you give. Your answer, 2,380, is not the correct result that your formula would give. You have either stated the formula incorrectly or you have made an error in your numerical work. The statement given in the Babcock & Wilcox catalogue is perfectly reliable. An approximate rule for finding the flow in pounds per second is given by Napier and is as follows: Flow in pounds per second = absolute pressure × area in square inches ÷ 70. Using your data with this rule we would have: Flow per second = $\frac{(90 + 14.7) \times .0123}{70}$ = .0184 lb. (.0123 = area of opening in square inches).

***

(45) Where can I obtain a copy of Newton's "Principia"? How many volumes are there? By whom is it published? What is the price, and is it difficult to understand?

J. B., Bridgeton, N. J.

ANS.—Every edition of Newton's "Principia" has been long out of print. The third edition, reprinted some years ago for Lord Kelvin and Prof. Blackburn, and also Motte's translation, can be obtained through Messrs. Macmillan & Bowes, booksellers, Cambridge, England. Lord Kelvin's reprint is, of course, in Latin, and Motte's translation is unsatisfactory. The best book for the general reader is "The First Three Sections of Newton's Principia, with an Appendix, and the Ninth and Eleventh Sections," by John H. Evans and P. T. Main. This book can be obtained from The Technical Supply Co., Scranton, Pa., for $1.00. Messrs. Evans and Main have translated these sections very carefully, and have added much explanatory matter. Their book can be read profitably by any person that has a good knowledge of geometrical conics.

***

(46) (*a*) How many pounds does a gallon of water weigh, and is the weight the same whether hot or cold water is used? (*b*) How many gallons in a cubic foot? (*c*) What is the weight of a cubic foot of cast iron? (*d*) How can I find the weight of a piece of wrought iron ⅞ in. in diameter and 20 ft. long? (*e*) How can I find the number of gallons of water in a tank 4 ft. 3 in. in diameter and 10 ft. high?

F. E. P., Bucyrus, Ohio.

ANS.—(*a*) The weight of water depends on its temperature and on its degree of purity. An average value for the weight of 1 U. S. gal. is 8.335 lb. (*b*) 7.481 U. S. gal. (*c*) 450 lb. (*d*) Wrought iron weighs .282 lb. per cu. in. The volume of a piece ⅞ in. in diameter and 20 ft. long is .7854 × .75² × 20 × 12 = 106.08 cu. in. Hence, the weight = 106.08 × .282 = 30 lb. nearly. (*e*) The volume of the tank is .7854 × (4¼)² × 10 = 141.86 cu. ft. One cu. ft. = 7.481 gal. Hence, tank contains 141.86 × 7.481 = 1,059.25 gal.

***

(47) Will you kindly tell me the ratio of air and gasoline for a gasoline engine, so that I can proportion the valves correctly?

A. H. G. L., Philadelphia, Pa.

ANS.—The proportions of gas and air vary from 1 to 5 up to 1 to 8 or more. It would probably be best to make the gasoline passage not less than one-fifth as large as the air passage. The flow of gasoline may then be under the control of a valve so that the proportion of gasoline may be varied, if necessary, to suit different conditions.

***

(48) (*a*) When the vacuum gauge on a suction pipe of a pump shows 26 in., how far is the pump sucking the water? (*b*) What is the difference between *friction* and *coefficient of friction* of water in pipes?

W. A. R., Pomona, Cal.

ANS.—(*a*) When the pump is at rest the water will stand in the pipe at a height of 29.5 ft., nearly, above the surface of the water in the well. When the pump is working, the water will not be lifted quite so high because of the friction in the pipe. (*b*) The *friction* is the resistance offered by the interior surface of the pipe to the flow of the water through it. The *coefficient of friction* is a number that is used in calculating the resistance due to friction when the length of the pipe, its diameter, the condition of its interior surface, and the velocity of the water flowing through it are known.

***

(49) I wish to build a dynamo for a gasoline-engine igniter. Please give me the windings. The armature is made of laminations 2½ in. × 1½ in. and the speed is 2,000. The field is of cast iron. About 16 volts and 2 amperes are required.

W. G. B., Muscatine, Iowa.

ANS.—You have not given enough data on this machine to enable us to give you any definite information. If you make a series-wound machine, you will probably need about No. 18 B. & S. on the field and No. 24 B. & S. on the armature for an output of 2 amperes. To generate 16 volts, you would need 600 or 700 turns on the armature. The above figures are, however, only very approximate, because we have not sufficient information to make accurate estimates.

***

(50) Is it possible to make a practical storage or plunge battery that will operate a 16 c. p. lamp? If so, would you kindly give directions for making one, the plunge battery preferred?

G. W. T., Pawtucket, R. I.

ANS.—It would be quite possible to run a 16 c. p. lamp from a plunge battery or storage battery. The storage battery would be much better than the plunge battery, as the latter would be expensive to maintain and troublesome to look after. Almost any type of plunge battery using bichromate-battery solution would answer, but a few cells of storage battery would be preferable. It would take more space than we can allow to give detailed instructions for making these batteries; we hope before long to publish an article telling how to make a small storage battery, and in the meantime would refer you to a book entitled "Small Accumulators, How Made and Used," by Percival Marshall; and "How to Make Electric Batteries at Home," by

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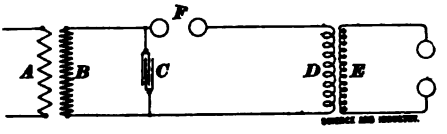
Trevert. The price of the first book is 50 cents and the second 25 cents. They may be obtained from The Technical Supply Co., Scranton, Pa.

***

(51) In the Encyclopedia Britannica, 9th edition, American Supplement, the circuit is shown for connecting a Tesla coil with an induction coil. The article also describes the number of turns of wire in both primary and secondary of one particular coil. Please inform me what the proportions must be in order to obtain a 6-in. spark: (*a*) of the induction coil; (*b*) of the condenser; (*c*) of the Tesla coil.
W. M., Chicago, Ill.

ANS.—(*a*) The Tesla coil is usually connected up as shown in the appended sketch. *A* is the primary of an induction coil and *B* its secondary; *C* is a condenser and *F* a spark gap between two brass balls; *D* is the primary of the Tesla coil and *E* is the secondary. When the condenser becomes charged, the high potential across its terminals causes a discharge across *F* that is oscillatory and of very high frequency, thus inducing a high E. M. F. in *E*. In place of using a regular induction coil at *AB*, a high-potential transformer is frequently used. Such a transformer should have a capacity of about 200 watts, and should give a secondary voltage of about 10,000 volts. A transformer of this kind is more satisfactory for this work than an induction coil. It would be impossible to give the number of primary and secondary turns without knowing the type of



transformer to be used. We would advise you to consult Nikola Tesla's book on "Experiments With High Potential and High Frequency." (*b*) For the condenser use a number of Leyden jars, and adjust the capacity to get the best results by varying the number of jars. The required capacity is small, and Leyden jars are good condensers, because their insulation resistance is high. (*c*) You can make a satisfactory Tesla coil by taking a glass tube 3 in. in diameter and about 7 in. long, and winding on it about 30 turns of No. 12 B. & S. wire in a single layer, spreading out the wire so that it will occupy about 6 in. length along the tube. For the secondary, take a 4-in. tube of the same length and wind on it as many turns of No. 24 wire as can be placed in one layer. Place the primary inside the secondary, and immerse the whole arrangement in kerosene oil.

***

(52) (*a*) Is the electric current from a dynamo actually made in the machine, or is it simply attracted from the invisible ether surrounding it? (*b*) At what amperage and voltage is an electric current dangerous to human life? (*c*) How are incandescent lamps made or varied for different voltage and current? (*d*) What is the rule for setting plain slide valves on engines and duplex steam pumps to give proper lead and expansion?
N. M. B., Velasco, Texas.

ANS.—(*a*) A dynamo does not generate an electric current, but establishes an electrical pressure between two points, and the flow of current is the result of this pressure. A pump causes a current of water to flow by establishing a difference in pressure, but the pump does not manufacture the water. We will have to know more about the exact nature of electricity before we can tell just where it comes from. (*b*) It is almost impossible to give any definite answer to this question, as the current and pressure depend on so many different conditions. The state of health of the person receiving the shock has a great deal to do with it. Generally speaking, pressures below 500 volts are not considered dangerous, hence the adoption of this pressure as the working limit for street railways. (*c*) The lamps are adjusted for different currents and voltage by using different sizes of filament. For low-voltage lamps the filament is short and thick, while for high-voltage lamps the filament must be of high resistance, and is therefore made long and of small diameter. The filaments always vary more or less, and, after the lamps are completed, they are tested, and the proper voltage marked on them. The variation, however, is not great, and when a large number of lamps are made the filaments can be so graded as to procure practically uniform results. (*d*) The answer to this question would take up more space than we could possibly give in these columns.

***

(53) In observing with a transit the easterly and southerly bearings of two old fences that intersect at right angles and are supposed to be on true lines, the compass needle read N 75° E on the easterly line, and on the southerly line it read S 15° E. "Gillespie's Surveying," page 175, states that "the true bearing will be the difference of the declination and a bearing which is north and west or south and east and the sum of the declination and a bearing which is north and east or south and west. A north bearing must be called N 0° E, a west bearing N 90° W, a south bearing S 0° W, an east bearing S 90° E." If the declination of the needle were 15° east at the time of the original survey of the lines, why is it that, for the easterly bearing, 16° subtracted from S 90° E gives S 75° E instead of N 75° E, and that, for the southerly bearing, 15° added to S 0° W gives S 15° W instead of S 15° E?
P. W. B., Kingsburg, Cal.

ANS.—According to the rule quoted, you would have, for the easterly bearing, S 90° + 15° E = S 105° E, which is the same as a bearing of N 75° E; and for the southerly bearing, S 0° — 15° W = S — 15° W, which is the same as a bearing of S 15° E. Your observations of the old lines, however, do not indicate that the declination of the magnetic needle was 15° east at the time of the original survey of the lines. If we assume the fences to be on true lines, as you state they are supposed to be, that is, on lines N 90° E (or S 90° E) and S 0° E (or S 0° W), the observations indicate that the declination is *now* 15° east. Assuming this to be the case and applying the rule quoted to the observed magnetic bearings, gives for the true bearings of the lines

N 75° + 15° E = N 90° E
S 15° — 15° E = S 0° E

Whatever the declination was at the time of the original survey, allowance was undoubtedly made for it, so that the bearings of the lines are probably due east and due south. This can be ascertained by determining the true bearings of the lines, by means of a solar observation or otherwise.

***

(54) (*a*) What mixture is used to illuminate air and steam gauges at night? (*b*) What is a good polish for brass? (*c*) Give me a good mixture of graphite for front ends and boiler heads to stand wet weather.
H. D. S., Stockton, Cal.

ANS.—(*a*) We suppose you mean the practice of painting the dial black and the hands and figures white. You may use ordinary black paint for the dial and a white enamel or a cake of Chinese white for the hands and figures. (*b*) Make a paste of the following ingredients: Rottenstone, 4 oz.; oxalic acid, 1 oz. (powdered fine); sweet oil 1½ oz.; enough turpentine to mix up. Apply with a little water and rub well with soft leather. (*c*) Use black iron varnish. Clean the smokebox, etc., and sandpaper it well; then put the varnish on thin. Wash down every morning with soap, water, and sponge.

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(55) In the Brush incandescent dynamo, does it make any difference in which direction the current runs; that is, is there any difference between the negative and positive brushes, and can the current be reversed? H. L., Buffalo Center, Iowa.

ANS.—If the machine is operating incandescent lights, it makes no difference, so far as the performance of the lights is concerned, which is the positive and which is the negative pole. You can reverse the polarity of the main leads of your circuit by reversing the connections of the mains to the dynamo. If you wish to reverse the polarity of the dynamo itself, you must reverse the field by reversing the connections of the shunt winding. If the machine were operating arc lamps, it would make a difference as to which side of the machine was positive and which negative, but in the incandescent work the polarity is immaterial.

***

(56) (*a*) Where can I get seamless steel tubing of the best quality, 14 inches inside diameter, and ¼ inch thick? (*b*) Where can I get steel castings made if I send drawings of the parts?

F. G. J., Rowley, Mass.

ANS.—(*a*) Communicate with The Charles A. Strelinger Co., Box K, Detroit, Mich.; or Montgomery & Co., 105 Fulton Street, New York, N. Y. (*b*) The Chester Steel Casting Co., Chester, Pa.

***

(57) (*a*) Please show me how to figure out spirals on the Brown & Sharpe milling machine. (*b*) What is the best method of drilling glass, crystal, and crockery? H. F., Montreal, Can.

ANS.—(*a*) You can find a full explanation of all calculations in regard to Brown & Sharpe milling machines in "A Treatise on Milling Machines," for sale by the Brown & Sharpe Mfg. Co., Providence, R. I. Price, in cardboard binding, 75 cents. To give you a full explanation of the calculations would require more space than we can devote to the subject. (*b*) Use a drill tipped with a diamond.

***

(58) I send you a piece of scale removed from the outside of a 4-inch iron blow-off pipe that has been in use for only two years. It is buried in ground, quite dry, sandy, and gravelly. Do you think this scale is caused by electrolysis? The electric railroad passes within 75 feet of the blow-off pipe. C. S., Newburyport, Mass.

ANS.—The sample of scale received does not allow us to judge whether it is a case of electrolysis or not. We could tell a great deal better if we saw the pipe itself. As you say the ground is quite dry, we doubt very much that electrolysis has anything to do with the decay of the pipe; to us it looks like a case of rusting, pure and simple. Protect the pipe by a wooden box filled with sawdust.

***

(59) What device is used on cable-car systems to keep cables from wearing at curves and corners? We have a curve or "knuckle" in a hoisting shaft, and wood-filled or rawhide-filled iron sheaves take the bearing of the skip cable. These wear out very fast and cause a great amount of bother. Could you suggest anything better? G. A. H., Rossland, B. C.

ANS.—We know of no other arrangement used for this purpose better than the rawhide- or wood-filled pulleys that you are already using. Rawhide is usually considered as good a material as can be found for use in these pulleys.

***

(60) How may the speed of a small battery motor having a two-pole field and a three-pole armature be increased? I have tried making the field stronger, and have also wound more wire on the armature, but this does not increase the speed.

W. Q., Philadelphia, Pa.

ANS.—Strengthening the field or winding more wire on the armature will, with a given amount of battery power, tend to lower rather than increase the speed. Your best plan will be to add more cells of battery and thus increase the E. M. F. applied to the motor.

***

(61) Will you please show me how to find the comparative efficiencies of an engine at different piston speeds, load and boiler pressure remaining the same? J. L. C., Topeka, Kan.

ANS.—A complete discussion of this problem would require more space than can be given to it in the Answers to Inquiries columns.

***

(62) Will you kindly give a solution of the problem involved in finding the correct dimensions of a lever 20 inches long, supported at the center, one end to carry one-half of a roll weighing 1,500 pounds, to which it must transmit an additional pressure of 6,000 pounds by means of a force applied to the opposite end? C. R. B., New York City.

ANS.—Questions that involve the design of machines or machine details cannot, in general, be answered in these columns. They are not of sufficient general interest to justify us in giving them the space they would require.

***

(63) (*a*) Why have all efforts to construct a successful rotary engine been failures; is it because they do not use steam economically? (*b*) Is the poor economy of rotary engines caused by the difficulty of using steam expansively in them, or is it due to their waste of steam by leakage? (*c*) Are you willing to give your opinion of the value of a patent on a rotary engine in these columns?

J. J. C., New Orleans, La.

ANS.—(*a*) Yes. (*b*) Both. (*c*) No; an expression of opinion on the value and practicability of patented inventions is a subject that we do not care to introduce into these columns.

***

(64) I have a 25-foot gasoline launch, with a 4-horsepower gasoline engine attached to a 20-inch two-bladed propeller making 380 revolutions per minute. Do you think I could get the same speed by the use of a jet propeller? What kind and size of pump would you advise to attach to the same engine? W. O. N., Grand Rapids, Mich.

ANS.—We would very strongly advise against making the proposed change.

***

(65) (*a*) How is the so-called "chilling" of iron castings accomplished? (*b*) I have some chilled car wheels that are worn. How can I draw the temper so as to be able to true them up, and how can I retemper them afterward? (*c*) How are shotguns polished on the inside? (*d*) Where can I get a mechanical magazine in the Portuguese language?

K. I. G., Alagoas, Brazil.

ANS.—(*a*) By using an iron mold. (*b*) These wheels are trued by emery wheels, just as they are. (*c*) After the finish-boring by means of a square reamer, the final finish is given with a wood or lead lap charged with emery. (*d*) We know of no such magazine.

***

(66) (*a*) I am told that an injector will not work if the delivery pipe taps the boiler above the waterline. Is this true? (*b*) What do you think of the prediction that the future universal use of electric railways will ruin agriculture by affecting the atmospheric electricity so much that clouds will not form, and, hence, no rain will fall?

L. D. K., Meadville, Mo.

ANS.—(*a*) Have never tried this, nor would we think of doing so; neither have we ever known it to be tried. It is for those that propose such a thing to adduce some reason for doing it. While there are obvious reasons for turning the injected stream into the body of water in the boiler, we cannot see any reason for turning it into the steam space, and we feel sure it would not work well, if at all. (*b*) We think you need not be alarmed on this score.

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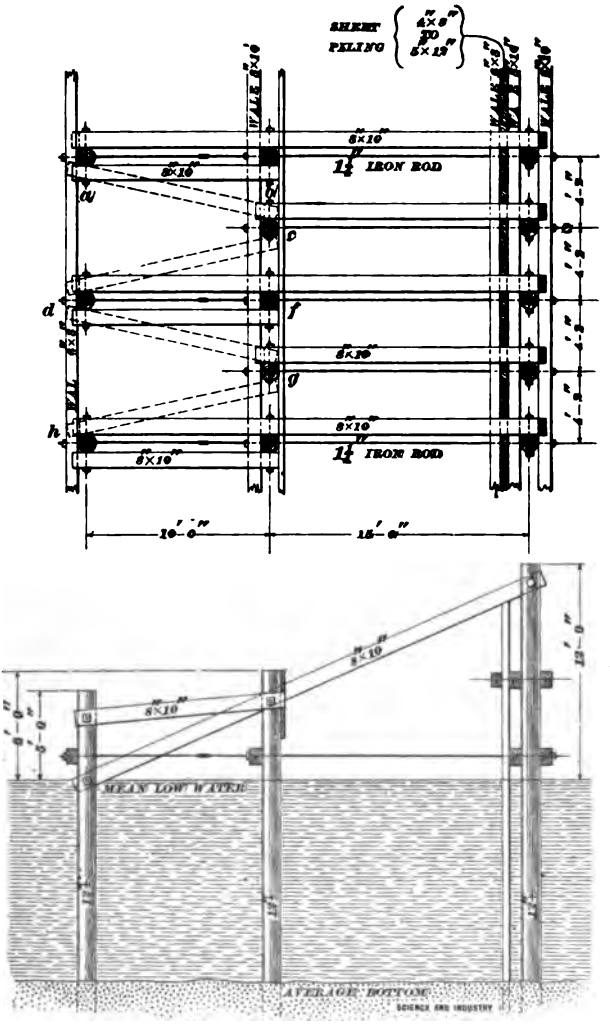
(67) In enclosed sketch, A designs revetment with piece *a b*. B says the function of this piece is zero and is a waste of material; it should be placed from *a* to *c*, and for further strengthening an additional piece *c d* used. A claims this would introduce oblique stresses, which is an objection. B says that a severe stress in *c c* causing the wale at *c*



to deflect should have *a c* or *a c* and *c d* to take up the excess stress. A claims that this stress is transferred through the wale to *b a* and *f d*; also, that the two back rows of piles are not designed as anchor piles but as a crib. The revetment is to be built in midstream of a tidal river with a rise and fall of about 6 ft. and it must stand heavy ice pressure and will not be filled in at first. Which is right? C. S. S., St. Davids, Pa.

ANS.—The piece *a b* would serve to hold the pile *a* in an upright position and thus increase its lateral resistance, which is essential if it is intended that the lateral pressure of the ice be resisted entirely by the row of piles *a d h*, but we can see no other advantage to be gained by using this piece. The diagonal pieces *a c*, *c d*, etc. would give some additional stiffness to the revetment. With this construction, however, it would seem advisable to increase the size of the wale *a d h*. We also suggest that, in order to sufficiently support the outer row of piles against the ice pressure before the crib is filled, it would seem necessary to place a timber strut along each of the iron rods, in the plane of the rods, which, we infer, is approximately the position of the plane of greatest pressure. In our opinion the design is susceptible of improvement.

***

(68) (*a*) How is a screw propeller fastened to the tailshaft of a marine engine? (*b*) What is the nature of the stuffingbox used on the tailshaft to prevent water from entering? (*c*) What means of lubrication are employed? (*d*) Is it advisable to mix sapolio shavings with the lubricating oil used in the bearings of a new engine?

J. A. T., Weedsport, N. Y.

ANS.—(*a*) The hub is bored out tapering to fit a tapered seat on the shaft. A feather is sunk half and half into the shaft and hub. The propeller is sent home by a large nut bearing against the after face of the hub. Suitable stops are provided to prevent this nut from slacking back. (*b*) The stern stuffingbox does not differ in any essential part from an ordinary stuffingbox and gland. It is usually packed with square flax packing, lubricated with tallow. (*c*) The gland is left loose enough for a little water to ooze through, the water lubricating the shaft. (*d*) In "The Steam-Electric Magazine," March, 1899, there is an article entitled "Curing a Hot Bearing," in which the author gives his experience with sapolio. You can draw your own conclusions from this article.

***

(69) (*a*) I have a small incandescent lamp that requires 7 volts and 1 ampere for 7 candlepower. Is this not at the rate of 1 candlepower per watt? Does not an ordinary lamp require about 3½ watts per candlepower, and what is the difference in the lamps? (*b*) What is the melting point of aluminum? What is the melting point of the alloy given for solder in SCIENCE AND INDUSTRY, November, 1899, Answers to Inquiries, No. 294?

E. L., Peekskill, N. Y.

ANS.—(*a*) An ordinary incandescent lamp takes about 3½ or 4 watts per candlepower. A lamp consuming 7 watts would not give 7 candlepower in all directions. By using a reflector, however, the rays may be concentrated in one spot so that it may be made to give an illumination of 7 candlepower over a small area. This is probably what is meant by stating that the lamp gives 7 candlepower. (*b*) The melting point of aluminum is about 700° C. We do not know the melting point of the alloy referred to.

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(70) How is gelatine for plaster casts made? Would common glue answer the purpose?

J. D. S., Eldridge, Cal.

ANS.—Yes.

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SCIENCE AND INDUSTRY

Vol. V MARCH, 1900 No. 2

IRON SMELTING AS A SOURCE OF POWER

Charles P. Turner

WASTE OF HEAT IN COKE PRODUCTION—METHODS OF UTILIZING THE VAST HEAT OF BLAST FURNACES—THE BLAST FURNACE AS A SOURCE OF POWER

IN CONJUNCTION with the subject of smoke prevention and the possibility of smokeless cities, it is interesting to consider a plan that, in addition to being a possible means of mitigating the smoke nuisance, promises wonderful results in changing the present status of the iron industry.

We are living in an age whose conditions depend on the use of iron to an extent exceeded only by the application of the latent energy of fuel to the world's work. The two most potent factors of our civilization, fuel and iron, are, in fact, dependent one on the other; and it is practically impossible to consider the uses and effects of one without including the other. The production of iron from its ores, and its manufacture into the myriad forms demanded by the industrial world, involve the consumption of such immense quantities of fuel as to threaten the exhaustion of the supply. On the other hand, the application of fuel to the development of power is almost entirely dependent on the use of iron in the construction of heat engines.

Electrical transmission has introduced an era in which a country with a limited fuel supply may have large manufacturing interests if provided with a liberal supply of water-power. In the present state of the art of iron making, however, no country without a large supply of fuel can be successful in the production of iron. In the United States the output of iron for the year 1899 will probably amount to nearly 14,000,000 tons, to smelt each ton of which there will have been used, on an average, nearly a ton of fuel, mostly in the form of coke. To produce this coke an aggregate of about 20,000,000 tons of coal must be mined. The difference between the coal mined and the coke consumed in the iron furnace represents a waste that is one of the most deplorable features of the methods of iron making now in use, especially when considered in connection with the modern tendency to utilize everything connected with the business of supplying the world's needs. The freshly mined coal is a complex mixture of carbon and volatile compounds of carbon and hydrogen. When heated in the absence of air, the volatile compounds are driven off in the form of combustible gases and condensable vapors, leaving the coke, which consists of fixed carbon combined with the ash of the coal. In much the greater number of cases, the gas and vapors produced by coking are worse than wasted. They rise from the "oven," as the simple masonry retorts in which the process is carried on are called, and burn with a smoky flame that makes the vicinity of a coke-oven plant one of the most weirdly desolate spots on earth. With the exception of the small part of the heat that goes to keep the temperature of the ovens high enough to carry on the process of distillation, all the heat of the volatile hydrocarbons, from 40 to 50 per cent. of the original heating value of the coal, is lost; and, if the ovens are located near a city, the burning vapors add greatly to the evils resulting from a smoke-laden atmosphere.

Recently, methods of coking have been invented that permit the utilization of the gases and vapors. That part of the gas not required for heating the retorts may be collected and used for heating or lighting purposes, or for driving gas engines; the vapors are condensed and furnish considerable quantities of tar and ammonia. Considered from the blast-furnace manager's

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standpoint, by-product coking systems, as the methods by means of which the waste of the ordinary systems may be utilized are called, are useful chiefly because they make it possible to manufacture a satisfactory quality of coke from grades of coal that would not be available in the ordinary processes. Where coal that makes a satisfactory quality of coke by the old methods is available, there seems to be little tendency to adopt by-product systems, as there is an apparent feeling of uncertainty in regard to the practicability of using by-product coke for blast-furnace work, a work in which the quality and quantity of the metal produced and the certainty of uniform results is considered more important than the money value of the by-products that might be saved. The old type of ovens have been thoroughly successful in supplying a grade of coke that seems to be an almost ideal blast-furnace fuel, and the supply of coal suitable for coke making in these ovens is so plentiful and cheap in the largest iron-making centers of this country that by-product coking has not made much progress. It is also argued by the advocates of the old systems that in the vicinity of the coke fields there is not sufficient demand for the great quantities of gas that would be produced to warrant the expense involved in an attempt to utilize it. When, however, we see large coke-oven plants polluting the air of a city with their waste, while, in their immediate vicinity, coal is being used for manufacturing a city gas supply, the coke from which is a product of small value, these arguments lose much of their force; and one is led to wonder what unknown conditions there may be that the managers are unwilling to reveal.

In addition to the portion of the energy of the coal used in smelting iron that passes off in the process of coking, there is another large part that was heretofore entirely lost, and is today but imperfectly utilized. Iron ore is a compound of iron with oxygen; and the process of smelting in a blast furnace is one in which the ore is brought into contact with the burning fuel under such conditions that there is a ready transfer of oxygen from the ore to the carbon, thus leaving the iron in a metallic state, while some of the carbon is oxidized.

The conditions are such, however, that a very small part of the energy of the fuel is absorbed in bringing about the transfer of oxygen from the ore to the carbon. Much the greater part of the carbon leaves the furnace in the form of carbon monoxide *CO*—a gas in which the carbon has combined with but one-half of the oxygen with which it is capable of combining, and developed less than one-third of the heat that it would have developed if combustion had been complete. This gas leaves the furnace mixed with large quantities of inert gases and dust, a condition that makes its utilization somewhat difficult. It has, however, for some time been employed in heating the blast for the furnace, a process that has greatly reduced the fuel consumption per ton of iron produced, and increased the output of the furnaces. Only a part of the available heat can be utilized in this manner; the remainder is being utilized by burning the gas under boilers to make steam for driving the blowing engines and for generating power for other purposes in connection with the manufacture of iron into the forms demanded by the consumers.

As long as the steam engine was the only practicable device for converting heat into mechanical energy, and no ready means were available for transmitting mechanical energy through considerable distances and distributing it to the points where it was most needed, the heat of the waste gases from the blast furnace was most imperfectly utilized, the gas was burned in the most wasteful manner, and the steam was used in engines whose economy was poor. With the advent of electrical and compressed-air transmission, however, the methods employed have been greatly improved, and modern American furnace plants are making use of the most improved types of boilers and engines. In addition to the power required for driving the machinery used around the furnaces, it is found that a considerable surplus is available for other purposes.

Recent developments in the construction and use of the gas engine are introducing a new factor in the problem of utilizing blast-furnace gases. As was stated above, the combustible portion of these gases is largely diluted with inert gases, and, what is worse, they carry great quantities of dust, which gives more or less trouble in the cylinder of a gas engine. Extensive experiments have, however, been made in Europe that indicate that, notwithstanding the disadvantages of dust and a dilute gas, blast-furnace gases can be successfully used in the gas engine. There are also indications that the waste gas from a ton of fuel that has been used for smelting iron in a blast furnace can, by means of the gas engine, be made to develop more power than is now obtained

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when the same amount of fuel is burned under a boiler, and nearly as much as could be obtained if the coke were made directly into gas for gas-engine driving.

A blast furnace is, in reality, an immense gas producer of the best type, and, if it is desired to make gas for power purposes on a large scale, it would be difficult to design a more satisfactory device for the purpose than a modern blast furnace. These facts, taken in conjunction with the recent success in the application of gas engines to large power units, have led to the very interesting conclusion that one of the most valuable products of blast-furnace plants of the future will be power in some form suitable for transmission and distribution, while the iron produced will be of secondary importance. Such a plan would involve the placing of the furnaces in the vicinity of large manufacturing centers, where there would be a ready market for both their products. If the demand for iron should be less than the possible output of the furnaces, they could still be run at a profit, merely for the purpose of supplying power. The only difference in their operation would be the omission of the charges of ore and a modification of the methods of driving, so as to secure the most profitable production of gas, the effect of the composition of the charge of fuel on the iron being no longer considered. Under such conditions furnace management would be greatly modified. Instead of working for the greatest possible production of iron with a minimum consumption of fuel, it would be necessary to consider the combined value of the two products of the furnace, and it might even be found profitable to restrict the iron output per ton of fuel. In consideration of the facility with which inferior grades of pig iron may now be made into steel, it might even be found profitable to sacrifice something in the quality of the iron to the production of a large and satisfactory supply of power gas from a quality of fuel that most furnace managers of the present would think wholly unfit for their purpose.

Disregarding, however, speculations as to the possible effects on furnace management of a plan that would make the blast furnace primarily a gas producer and only incidentally a device for the manufacture of pig iron, let us consider a few facts and figures relating to existing conditions. Let us assume that instead of being worse than wasted in polluting the atmosphere and desolating everything in their vicinity, the by-products of coking are carefully utilized. Also, let us assume that the best possible use is made of the waste gases from the blast furnace. Calculations made by good authorities seem to prove that the gas engine provides a means of developing from these waste products as much power as is now obtained with a good steam engine when using a weight of coal equal to that from which the coke was made. Assuming a coal consumption of 3 pounds per horsepower-hour as the average for good steam plants, and that the possible power production of the coal from which our blast furnaces are supplied with coke is the same, the waste from the 20,000,000 tons of coal now mined for the blast furnaces of the United States could be made to develop more than 4,000,000 horsepower for 10 hours per day and 300 days in the year. A considerable portion of this power would be required in the operation of the furnaces; in fact, it is by no means all wasted under present methods of operation. There is, however, little doubt that a surplus of at least a half of what we have estimated, or 2,000,000 horsepower, might readily be made available for other purposes.

The engineering world looks with admiration on the power developments at Niagara, and the advantages offered by proximity to such a supply are the envy of all manufacturing people not so blessed. The prospective developments at Niagara, however, provide for the generation of but little more than one-tenth as much power as we have shown might be obtained from the wastes from the manufacture of pig iron, and whose development per unit of power would cost far less than is being expended at Niagara.

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SERIES INCANDESCENT LIGHTING BY ALTERNATING CURRENT

R. B. Williamson, M. E.

DESCRIPTION OF SIMPLE TRANSFORMER—TRANSFORMER WITH ADJUSTABLE SECONDARY—AUTO-TRANSFORMER REGULATOR—REGULATOR WITH PLUG SWITCH

IN A previous article, one common method, by means of which incandescent lights might be run in series from an ordinary alternator, was described. Some of the objections to this system were pointed out, one of the principal of these being that it was necessary to cut in lamps at the station in order to take the place of those that might happen to burn out on the line. The advantages of the series-system of lighting are so great for many special cases that various devices have been devised to render the system more flexible, and to effect the regulation necessary with but very little loss of power and with small outlay for apparatus.

It is desirable, in the first place, to have some arrangement by means of which the pressure applied to the series of lamps may be varied through wide limits. If this can be done, it is clear that circuits may be operated in which the number of lamps is widely different from that called for by the voltage of the dynamo. One of the principal objections to the old system was that any difference in voltage between that required by the lamps and that generated by the dynamo had to be taken up at the station either by lamps or some other resistance. It is also desirable that the regulating apparatus shall use up as little power as possible, and, in this article, we will describe one of the more recent regulating arrangements brought out by the General Electric Company for use in connection with these circuits.

This regulator is shown complete in Fig. 1, and its construction and operation will be understood from what follows; it involves the use of a special transformer and there are a number of interesting features connected with its operation. Nearly every person that has had anything to do with an electric-light station or is at all interested in electric-lighting work, is familiar with the construction of the ordinary transformer. In its simplest form, it consists of the three essential parts shown in Fig. 2; *P* and *S* are coils of wire wound around the iron core *C*. The coil *P* is called the *primary*, and is connected to the alternator; while the coil *S* is called the *secondary*, and is connected to the lights. When an alternating current flows through the primary, it sets up magnetism through the iron core, and this magnetism is continually changing as the primary current changes. The result is that the magnetism threading the coil *S* induces an E. M. F. in it. If the number of turns in the secondary is

FIG. 1

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large, the induced E. M. F. will be high. For example, if the primary coil had 1,000 turns and the secondary also 1,000 turns, the E. M. F. induced in the secondary coil would be very nearly the same as the E. M. F.

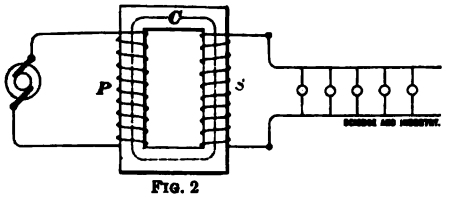

FIG. 2

supplied by the alternator. If the number of secondary turns were one-half that of the primary, the E. M. F. obtained from the secondary would be one-half that in the primary; in fact, the secondary E. M. F. is equal to the primary E. M. F. divided by the ratio of the number of primary turns to the number of secondary turns.

Suppose, now, that the secondary were split up into a number of sections, as shown in Fig. 3, and these sections brought out to different points of a switch. When the switch is on point *1*, the whole of the secondary is connected to the series of lamps *l*, *l*; when it is on point *2*, one section of the winding is cut out, and the E. M. F. applied to the circuit is correspondingly diminished. By placing an ammeter in the circuit, it is readily seen that, should one or two lamps happen to burn out and the current thereby tend to increase, it may be brought back to the correct value by cutting out part of the secondary coil. This arrangement would then give a method of adjusting the voltage applied to the line from the full amount generated by the secondary coil down to zero, if necessary. Generally, the secondary coil would be wound for a high voltage, as the number of lamps operated per circuit would require a voltage nearly equal to that of the dynamo.

A transformer, such as the above, might be used for this work, but it has been found advisable to modify it, although the principles involved are the same. It will be noted that the two coils, primary and secondary, are entirely distinct, and in no way connected with each other. This is the construction usually followed in ordinary transformers, because the secondary circuit is, in most cases, of very much lower voltage than the primary circuit, and it would not be desirable to have the low-tension secondary connected in any way to the high-tension primary. There is not so much need of keeping the two coils separated when the secondary voltage is nearly the same as the primary, and this is the state of affairs when incandescent lights are operated in series. Suppose two coils *A B* and *B C* are wound on an iron core, as shown in Fig. 4, these two coils being connected in series. Connect the primary wires from the alternator to *A B* and those from the secondary, or lamp circuit, to *A C*. We will now have a transformer in which the same winding serves both for the primary and secondary coils. Current will flow from the mains through *A B*, and will set up magnetism in the core. This magnetism will generate a pressure in *B C*, and this pressure will be *added* to that of the primary, thus making the pressure across the secondary greater than that generated in the primary by the amount generated in *B C*. Such an arrangement is sometimes called an *auto-transformer*. If, however, the connections of the winding *B C* were reversed, as shown in Fig. 5, the voltage in *B C* would be *subtracted* from that of the line, and the pressure across the secondary could be made much lower than that of the line. If, in addition to having some means of reversing these connections, we also have the portion *B C* divided into

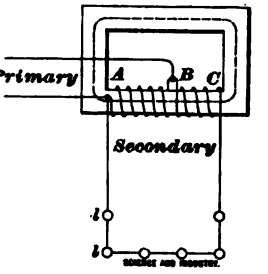

FIG. 4

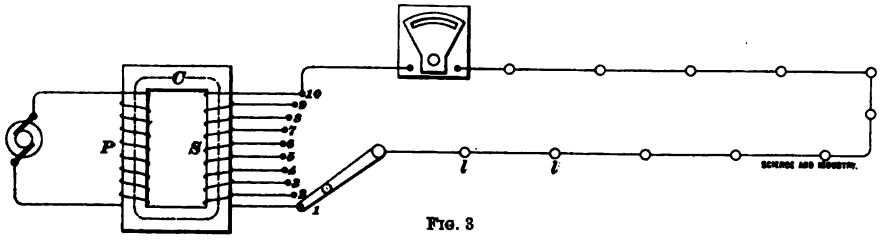

FIG. 3

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sections, it will be readily seen that the secondary voltage may be varied, by gradual steps, from a point considerably above that of the line to a point the same amount below it. Suppose, for example, that the line voltage were 1,000, and that the coil *B C* were wound for 200 volts. A range of voltage on the secondary could then be obtained from 1,200 volts to 800 volts.

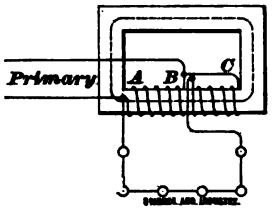

FIG. 5

This is accomplished as indicated in the diagram, Fig. 6; *A B* represents one section of the winding and *C D* the other. The coil *C D* is split up into a number of sections, as shown, and the terminals of these sections are brought to the contact plates *a*. Two sliding arms *e*, *f* make connection between these blocks and the contact arcs *g*, *h*. The arms *e*, *f* are moved by means of a hand wheel, one of them being operated directly, and the other through gearing, so that when one rotates in one direction the other moves in the opposite direction, thus allowing both arms to move over the whole range of the contact pieces. In order to accomplish this, the arms must, of course, be arranged so that they can slide one over the other. One side of the lamp circuit is connected to *h* and the end of the coil *A B* connects to *g*. An ammeter is also included in the circuit, so

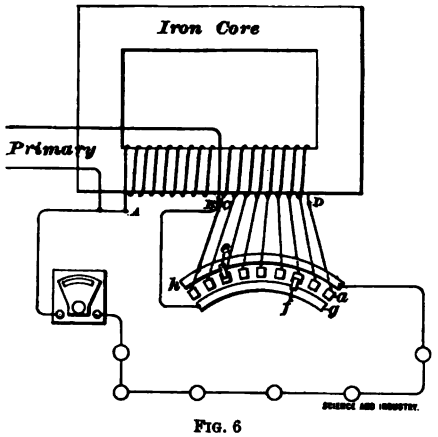

FIG. 6

that the current can be accurately adjusted. By tracing out the connections it will be seen that when arm *f* is at the extreme left, arm *e* will be at the extreme right, and the whole E. M. F. of *C D* will be added to that of *A B*. When the arms are in the other extreme position, the E. M. F. of *C D* is subtracted. Any intermediate voltage between these two limits can also be obtained, the secondary voltage being that of the primary, plus or minus the voltage generated in the winding included between the two arms. If both arms were in the middle position, they would both be on the middle contact block, and the secondary voltage would be the same as the primary.

In the ordinary regulator, the primary is wound for 1,100 or 2,200 volts, and for a line

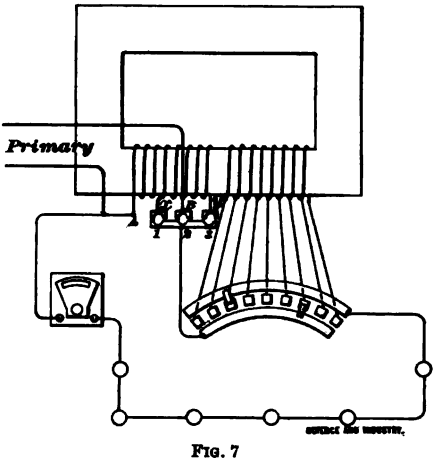

FIG. 7

current of 3.5 or 5.5 amperes. The adjustable portion of the winding is wound for 230 volts, with a sufficient number of taps to give 23-volt sections. The regulator, therefore, allows adjustment from 870 to 1,330 volts in the 1,100-volt regulator, and from 1,970 to 2,430 in the 2,200-volt regulator. This range is ample for all ordinary requirements, but in some cases a greater range might be required if, for example, it were desired to run a circuit carrying a number of lamps either greatly above or below the ordinary number. This is accomplished as shown in Fig. 7. The connections to the coil *A B* are the same as before, but three taps are brought to the plug contacts *1*, *2*, and *3*. We will suppose, for the present, that the regulating switch is at its middle position, and may, therefore, be left out of account so far as its affecting the voltage is concerned. The voltage on the secondary line will then be equal to that in the primary coil; for example, when the plug is in *2*, the secondary voltage will be the same as that between *A B*; when it is in *1*, the secondary

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voltage will be equal to the primary voltage, less the voltage generated in $x B$. When the plug is in 3, the secondary voltage will be equal to the primary plus the voltage generated in $B y$.

The effect of the plugging arrangement is, then, to increase largely the range of the regulator, the regulating coil being used for obtaining just the intermediate voltage required. The regulators made with this plugging attachment give a variation in voltage from 440 to 1,760 on the 1,100-volt regulator, and 1,540 to 2,800 on the 2,200-volt regulator. The general appearance of the regulator with the plug attachment is shown in Fig. 1. The plug switch is located at the bottom of the board, and a knife switch is placed near the top, to disconnect the lamp circuit from the dynamo and regulator.

It will be seen from the above description that a special transformer of this type enables the current to be adjusted, even though there is a wide range of variation in the number of lamps operated. The loss of power is also small, because the transformer is not large, and the various losses in it do not amount to very much, so that in this respect it is far better than the old method of cutting in lamps at the station.

The series incandescent system cannot, of course, compete with the arc light for illuminating large areas, but it is very useful for lighting streets that are thickly shaded by trees. It is also a system that requires little attention and gives good results if the lamps are kept up to their full candlepower. If the line current is not kept at the right value, the system will not give satisfaction, and this is where the regulator plays an important part. There are a number of other modifications of the transformer that have been applied to this work, and the above has been selected as an example of one that brings out most of the important principles involved, and serves as a good example of one of the many uses to which the transformer has been put.

THE EFFICIENCY OF FUELS

Walter B. Snow

HEAT LOSSES IN A BOILER—REDUCTION OF HEAT LOSSES INCIDENTAL TO THE EMPLOYMENT OF MECHANICAL DRAFT—SOME TESTS WITH INDUCED DRAFT

THE potential efficiency of a fuel is, naturally, to be measured by the total amount of heat that it is capable of generating, as compared with some other combustible accepted as a standard. The efficiency thus measured is, of course, independent of the means provided for utilizing the heat. Such a means is the steam boiler, and to its design and construction are chargeable numerous losses incident to the burning of fuel for steam generation.

The potential or heat value of a fuel is, naturally, to be determined by chemical analysis, or by means of a fuel calorimeter. If, merely for the purpose of comparison, we accept pure carbon as a basis, we shall have relative fuel efficiencies based on the thermal units in 1 pound of coal, as indicated in columns 2 and 3 of Table I, pure carbon having a heat value of 14,650 B. T. U. This value may be actually exceeded by a coal that is strong in hydrogen and leaves little ash. To indicate the damaging effect of the losses incident to burning in connection with an ordinary boiler, the succeeding columns of Table I have been added. A boiler efficiency of 60 to 70 per cent., doubtless, represents average practice. Hence, a fuel having a heat value of, say, 12,000 B. T. U., or only 82 per cent. of that of pure carbon, will, when burned in connection with a boiler having an efficiency of only 60 per cent., show a resulting utilization of heat that represents only $.82 \times .60 = 49.2$ per cent. of the total heat value of the carbon.

The highest practicable efficiency of a modern boiler plant, with mechanical means of draft production and devices for heat utilization, is about 90 per cent. of the total heat value of the fuel. Between this and 60 to 70 per cent. is the vantage ground within which economic gain may be sought. Other things being equal, the first consideration regarding the efficiency of fuel with mechanical draft is concerned with the thoroughness of the combustion; in other words, with the heat value of the products of combustion obtained from a given quantity of fuel. This is not merely to be measured in thermal

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units, but the intensity of the temperature is also of great importance; that is to say, there is more utilizable value in 10,000 cubic feet of gases at 600° than in 20,000 cubic feet at 300°. The difference in volume is due to the difference in the amount of air supplied per pound of coal; coincidently, the greater the air supply, the less the temperature. Hence, the larger volume passes with greater speed across the boiler surfaces, and has less time to part with its heat, while at the same time the lower temperature of the gases reduces the rate of transmission by heat.

TABLE I

EFFICIENCY OF FUELS

British Thermal Units in 1 Lb. of Fuel.	Water Evaporated From and at 212° per Lb. of Fuel. Theoretical.	Efficiency of Fuel. Theoretical.	Efficiency of Boiler.				
			90%	80%	70%	60%	50%
			Efficiency of Fuel.	Efficiency of Fuel.	Efficiency of Fuel.	Efficiency of Fuel.	Efficiency of Fuel.
14,650	15.2	100.0	90.0	80.0	70.0	60.0	50.0
14,500	15.0	99.0	89.0	79.2	69.3	59.4	49.5
14,000	14.5	95.6	86.0	76.5	66.9	57.4	47.8
13,500	14.0	92.2	83.0	73.8	64.5	55.3	46.1
13,000	13.5	88.8	79.9	71.0	62.2	53.3	44.4
12,500	12.9	85.4	76.9	68.3	59.8	51.2	42.7
12,000	12.4	82.0	73.8	65.6	57.4	49.2	41.0
11,500	11.9	78.6	70.7	62.9	55.0	47.2	39.3
11,000	11.4	75.2	67.7	60.2	52.6	45.1	37.6
10,500	10.9	71.8	64.6	57.4	50.3	43.1	35.9
10,000	10.4	68.3	61.5	54.7	47.8	41.0	34.2
9,500	9.8	64.9	58.4	51.9	45.4	38.9	32.5
9,000	9.3	61.4	55.3	49.1	43.0	36.8	30.7
8,500	8.8	58 0	52.2	46 4	40.6	34.8	29.0

The apparently paradoxical result is that within the usual range of boiler practice an increase in the air supply per pound of fuel actually increases the temperature of the gases as they escape to the chimney, and, consequently, increases the amount of heat that is absolutely wasted. With mechanical draft it is possible, because of its greater intensity, to carry fires of greater depth and to secure higher efficiency in the utilization of the air. As a consequence, perfect combustion can be accomplished with less air and less waste than with chimney draft. It is further true that under proper conditions, such as can be secured with mechanical draft, better efficiency is secured with moderately high than with low rates of combustion.

A most excellent illustration of this fact is presented in Table II. This covers the results of tests with the Wilkinson stoker operating at different rates of combustion. The construction of this stoker is such as to present an excellent opportunity for intimate contact of fuel and air. The results indicate that with a combustion rate of 45.4 pounds per square foot of grate surface per hour, the air supply was actually less by 11.2 per cent. than the amount chemically required by the fuel; under these conditions, an evaporation of 11.69 pounds of water from and at 212° per pound of combustible was recorded. As a result of this deficiency in air supply a certain amount of carbonic oxide is necessarily formed. But with the perfect utilization of air supply that

TABLE II

AIR SUPPLY WITH DIFFERENT RATES OF COMBUSTION ON A WILKINSON AUTOMATIC MECHANICAL STOKER

Buckwheat Coal Burned per Hour per Sq. Ft. of Stoker Grate. Pounds.	Air Theoretically Required to Burn 1 Lb. of Buckwheat Coal. Cubic Feet.	Air Actually Supplied to Burn 1 Lb. of Buckwheat Coal. Cubic Feet.	Percentage of Excess or Deficiency of Air Supplied.
12.0	125	232	+ 85.6
18.0	125	157	+ 25.6
25.2	125	132	+ 5.6
32.5	125	123	— 1.6
41.5	125	111	— 11.2
45.4	125	111	— 11.2

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is available the loss by formation of carbonic oxide is less than that which would occur as the result of heating the large volume of air that would have to be provided under less favorable conditions.

The efficiency with which coal may be burned depends to a material degree on the size of the coal, the small coals requiring more intense draft, as they present but little opportunity for the circulation of air around the particles, and because most of them contain a large percentage of non-combustible matter that remains as ash. As a rule, however, the low-grade fuels of this character are commercially the more efficient, provided they can be burned successfully; that is to say, it is usually the case that the cost of fuel generally decreases more rapidly than does the evaporative efficiency. In so far as the intensity of draft produced by mechanical means makes possible the burning of such fuels, the saving may properly be credited to the method of draft production.

TABLE III
EFFECTS OF EXCESS OF AIR

Excess of Air, in Per Cent., of Amount Chemically Required.	Total Weight of Air. Pounds.	Total Weight of Products of Perfect Combustion. Pounds.	Ideal Temperature Above 62° in Heart of Fire. Degrees.	Relative Volume of Gases at Ideal Temperature Above 62°.
0	9.04	9.84	5,053	1.00
50	13.56	14.36	3,461	1.04
75	15.82	16.62	2,982	1.06
100	18.08	18.88	2,633	1.09
125	20.34	21 14	2,351	1.11
150	22 60	23.40	2,124	1.13
175	24.86	25 66	1,937	1.15
200	27.12	27.92	1,780	1.17

The rate at which coal should be fed to a furnace is largely dependent on its character. It is doubtless true that the feeding is usually in too large quantities or too great intervals. Hence, the economy claimed for the mechanical stoker that feeds constantly at a rate proportional to the requirements. In tests conducted on two kinds of coal by M. Burnat, coal was, in eight different experiments, fed at the constant rate of 225 pounds per hour and burned at the rate of 10.8 pounds per square foot of grate, the air supply remaining practically constant. The rate of feeding was, of necessity, the average of the charges, which ranged from 13.3 pounds up to 55.4 pounds per charge. In the first set of experiments, the evaporative efficiency was 3.03 per cent. higher with the most frequent charging, and in the second set, 8.19 per cent.

Smoke is primarily due to inadequate air supply and mixture with fuel and gases. The loss by this means is not ordinarily very great, notwithstanding its apparent magnitude. Doubtless, 1 per cent. of the total amount of coal fired would represent the maximum in general practice. But it is not because of this loss that smoke is so objectionable; it is rather because of its contaminating effect on the atmosphere—an effect so great as to bring about the passage of restrictive regulations that, when duly enforced, necessitate the prevention of smoke or the suspension of business. While mechanical draft cannot be presented as a distinct smoke preventive, nevertheless the fact that it can supply air at any desired pressure, and in any required volume, renders it available as one of the best means of assisting in the abatement of the smoke nuisance.

Although we hear much regarding the losses by the formation of carbonic oxide instead of carbonic dioxide, or carbonic acid, as it is more commonly called, nevertheless the loss by the formation of carbonic oxide is usually very small—seldom over 1 per cent. in good practice. But unfortunately there are conditions under which the air supply is so inadequate as to furnish only a portion of the oxygen necessary for complete combustion. It is under such conditions that mechanical draft becomes of prime importance in increasing the efficiency. The positive and ample supply resulting from the employment of mechanical means serves to meet all requirements and to reduce the amount of carbonic oxide to a negligible quantity.

In connection with the prevention of both smoke and carbonic oxide, the admission of

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air above the fire is usually of considerable importance. In order to render this possible, it is usually necessary to employ the induced principle, so that the partial vacuum produced within the combustion chamber will cause inward flow of air through special openings in fire-doors and elsewhere.

Whenever the arrangement is warranted, much more positive results are, however, secured by using the forced-draft method and arranging it so that most of the air is discharged beneath the fires, and the remainder sprayed across the top of the fuel, thereby supplying, at the proper moment, the additional amount of oxygen that may be needed.

The twofold loss of heat due to an excess of air supply has already been alluded to. frequently much exceeded. With good arrangement of mechanical draft 50 per cent. excess can be made serve the requirements and bring about consequent saving due to higher temperature secured in the furnace.

This problem of heat loss in the escaping gases is the most important in boiler practice, for here exists the greatest opportunity for saving. Table IV serves to indicate most clearly how these losses mount up with the temperature and excess of air. They are figured for a coal having a heat value of only 11,720 B. T. U.

With the conditions that prevail when a chimney is employed to produce draft, an excess air supply of 100 per cent. is to be considered common practice, as is also a

TABLE IV

LOSS OF EFFICIENCY DUE TO EXCESS OF AIR, AND TEMPERATURE OF ESCAPING GASES ABOVE ATMOSPHERE

Excess of Air in Per Cent. of That Chemically Required.	Temperature of Escaping Gases Above Atmosphere.											
	300°		350°		400°		450°		500°		550°	
	Total B. T. U. in Gases.	Loss in Per Cent. of Total Heat Value of Coal.	Total B. T. U. in Gases.	Loss in Per Cent. of Total Heat Value of Coal.	Total B. T. U. in Gases.	Loss in Per Cent. of Total Heat Value of Coal.	Total B. T. U. in Gases.	Loss in Per Cent. of Total Heat Value of Coal.	Total B. T. U. in Gases.	Loss in Per Cent. of Total Heat Value of Coal.	Total B. T. U. in Gases.	Loss in Per Cent. of Total Heat Value of Coal.
0	695	5.9	812	6.9	928	7.9	1,044	8.9	1,160	9.9	1,276	10.9
50	1,016	8.7	1,185	10.1	1,354	11.5	1,524	13.0	1,693	14.4	1,862	15.9
75	1,176	10.0	1,372	11.7	1,568	13.3	1,764	15.0	1,959	16.7	2,155	18.4
100	1,336	11.4	1,558	13.3	1,781	15.2	2,003	17.0	2,226	19.0	2,448	20.9
125	1,495	12.7	1,745	14.9	1,994	17.0	2,243	19.1	2,492	21.2	2,742	23.4
150	1,655	14.1	1,931	16.5	2,207	18.8	2,483	21.1	2,759	23.5	3,035	25.9
175	1,815	15.5	2,118	18.0	2,420	20.6	2,715	23.1	3,025	25.8	3,228	28.4
200	1,975	16.8	2,304	19.6	2,633	22.4	2,957	25.2	3,291	28.0	3,621	30.8

The effect of air supply in varying amounts in excess of that chemically required in the case of a coal containing 80 per cent. of carbon is clearly shown in Table III. The ideal temperature is that to which the products of combustion would be heated if no losses occurred. It is to be noted that under the conditions given, the ideal temperature is reduced from 5,053° above the atmosphere to 2,633°, by the admission of twice the amount of air theoretically required.

Unfortunately, in modern boiler practice, it is usually impossible to secure reasonably perfect combustion without some excess. With a chimney, this usually amounts to about 100 per cent., although temperature of the escaping gases of not less than 450° above the atmospheric temperature, except in what may be called thoroughly good plants. This shows a loss of 17 per cent.; with a better coal it might readily amount to 25 per cent. of the heat value of the fuel thus actually discharged up the chimney and thrown away. This loss is absolute; with a chimney it is usually necessary in order to produce the draft. Tests by Donkin and Kennedy showed, as the results of seventeen different experiments, losses ranging as high as 31.8 per cent. When mechanical draft is employed, none of this heat is actually necessary to the operation of the fan; in fact, if it acts on the induced principle, the lower the

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temperature, the less the size and speed of the fan required, and the smaller the amount of power necessary to operate it. As a result, with mechanical draft all the heat is rendered available for utilization by feedwater economizers, heaters, etc. Although these naturally introduce added resistance, this is easily overcome when the fan is employed, and positive but flexible draft is maintained. It is for this reason that the fan has come to be considered largely as an adjunct to the economizer, by means of which it is enabled to render the most efficient service.

The saving to be secured by introducing an economizer depends on the conditions. It is undoubtedly true that the attempt is often made to apply this device on plants that are too small to warrant the expenditure. It is further true that the commercial efficiency of the economizer depends primarily on the cost of coal. A saving of 10 to 20 per cent. with coal costing $5.00 per ton is very different from the same percentage of saving when the cost is but $2.00. The first may show a handsome return on the investment, while the second may record a dismal failure.

The possibilities in the way of heat utilization by means of economizers are presented in Table V, which gives results under various conditions as reported by Barrus.

TABLE V

TESTS WITH ECONOMIZERS

Remarks.	Designation of Boiler.				
	I.	II.	III.	IV.	V.
Area of heating surface, boiler ..... square feet	1,984	4,058	5,592	3,126	1,880
Area of heating surface, economizer ..... square feet	1,600	1,920	1,280	1,600	1,600
Temperature of gases leaving boiler ..... degrees	376	361	408	485	618
Temperature of gases leaving economizer ..... degrees	231	254	299	279	365
Temperature of feedwater entering economizer ... degrees	95	79	111	84	88
Temperature of feedwater entering boiler ..... degrees	175	145	169	196	225
Increased evaporation produced by economizer, per cent.	10.5	7.0	9.8	12.8	29.0

TABLE VI

RESULTS OF TESTS OF ELLIS & EAVES INDUCED-DRAFT SYSTEM WITH STURTEVANT FAN

Items.	Number and Conditions of Test.		
	I. No. 1 Boiler, Plain Tubes With Retarders.	II. No. 1 Boiler, Plain Tubes With Retarders.	III. No. 2 Boiler, Serve Tubes With Retarders.
Date 1894	Sept. 28.	Oct. 5.	Sept. 29.
Duration of test ..... hours	6	6	6
Average steam-gauge pressure ..... pounds	96	95	96
Average temperature of feedwater ..... degrees F.	157	166	165
Average revolutions of fan per minute	507	472	468
Total water evaporated ..... pounds	72,661	59,708	71,697
Total coal burned ..... pounds	11,000	8,920	8,715
Total combustible consumed ..... pounds	9,746	7,780	7,717
Coal burned per square foot of grate per hour ..... pounds	52.08	42.23	41.26
Water evaporated per pound of coal from and at 212° ... pounds	7.228	7.274	8.939
Water evaporated per pound of combustible from and at 212° ..... pounds	8.165	8.332	10,097
Average temperature at fan outlet ..... degrees F.	625	527	456
Average temperature at fan inlet ..... degrees F.	650	547	472
Average temperature at air down-take ..... degrees F.	400	347	315
Average vacuum at fan inlet ..... inches of water	7.33	6.61	6.45
Average vacuum over fires ..... inches of water	3.88	3.46	3.56
Average vacuum under fires ..... inches of water	1.72	1.38	1.48
Average vacuum at air down-take ..... inches of water	0.62	0.58	0.50

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In cases I, II, III, and IV the average temperature of the gases leaving the boiler is comparatively low—394°—but the initial temperature of the water is raised 92° on the average, and the evaporation increased 9.9 per cent. per pound of coal. If this result is applied to a 1,000-horsepower plant, with coal costing, say, $60 for a day's run of 10 hours, the daily saving would be $5.94. For a year of 308 working days this represents a total saving of $1,829.52. An economizer equipment to secure the above results would probably cost from $6,000 to $7,000. The saving would represent an annual return of 23 to 26 per cent., certainly sufficient to warrant careful consideration.

Case V presents conditions under which an economizer is bound to show up to advantage. Figured on the same basis as the others, it shows a maximum return of nearly 75 per cent. Inasmuch as in any of the cases the cost of a fan would be far less than that of a chimney to produce the same results, there is evidently a definite and substantial net saving.

Other forms of heat abstracters in connection with which mechanical draft is still more of a necessity are those that heat the air supply to the fires and those in the form of ribbed fire-tubes that serve to transfer more heat from the gases to the water. In both the resistances are considerable—how great in the former type is clearly displayed in Table VI.

In this form of air heater or heat abstracter the fan is an absolute necessity and operates at excessively high pressure, the greatest vacuum recorded in these tests being 7.33 inches of water at the fan inlet. This, however, brings about a combustion rate of 52.08 pounds of coal per square foot of grate per hour. The gain in evaporative efficiency shown in test III is due primarily to the use of Serve tubes, which are internally ribbed and, in connection with the retarders (which are spirally coiled metal strips within the tubes), serve to transfer a considerable amount of heat. It is to be noted that the fan-outlet temperature of the gases was high—being 650°—in the first case, and hence there was a good opportunity for its reduction. The boilers were internally fired, and of the Scotch type. In such a boiler the temperature of the gases is usually high.

In summary, it appears that certain losses incident to boiler operations are unavoidable, such, for instance, as the conversion of the water in the coal and air into steam; the heating of the gases to the minimum temperature at which the plant can be economically worked; the waste in hot ashes, and also the heat waste through walls. Other losses are, to a greater or less extent, avoidable, such as those resulting from excess of air, high temperature of escaping gases, and imperfect combustion. It must be evident from the preceding discussion that mechanical draft is a most, if not the most, important factor in their reduction.

HOW TO OPEN A NEW BOOK

HINTS FROM A FAMOUS BINDER

"HOLD the book with its back on a smooth or covered table; let the front board down, then the other, holding the leaves in one hand while you open a few leaves at the back, then a few at the front, and so go on, alternately opening back and front, *gently* pressing open the sections till you reach the center of the volume. Do this two or three times, and you will obtain the best results. Open the volume violently or carelessly in any one place, and you will likely break the back.

"*Never force the back.* If it does not yield to gently opening, rely upon it the back is too tightly or strongly lined.

"A connoisseur, many years ago, an excellent customer of mine, who thought he knew perfectly how to handle books, came into my office when I had an expensive binding just brought from the bindery, ready to be sent home; he, before my eyes, took hold of the volume, and, *tightly holding* the leaves in each hand, instead of allowing them *free play*, violently opened it in the center and exclaimed, 'How beautifully your bindings open!' I almost fainted. He had broken the back of the volume and it had to be rebound."—From "*Modern Bookbinding Practically Considered*," by WILLIAM MATTHEWS.

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AN ARCHITECT'S DREAM

Thos. N. Thomson

A Brief History of Open Fires—Improvements Made in the Past—The Modern Ventilating Grate—Prince Helios' Ideas of the Fireplace of the Future

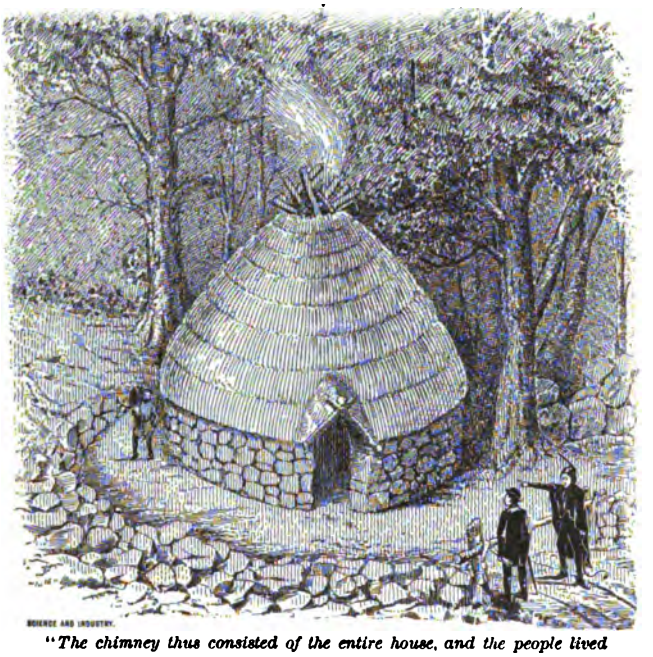
"IT CANNOT be, Mr. Goldberg. I have consulted several heating engineers on the matter and they agree that it cannot be done satisfactorily. They all advise the installation of a separate steam or hot-water heating plant to operate in conjunction with the open fireplaces, and I think you—"

"Think nothing," shouted Goldberg, "I tell you it *must* be done. There is no such word as cannot, and it *will* be done, for I won't have anything modern in this building. You know we have planned everything extremely antique—followed the lines of the ancients all the way through—and with a lot of study we have reduced the entire structure to simplicity and first principles; so why should we now spoil the whole scheme with a complex modern heating system? I *will* have open fireplaces, sir, and nothing but open fireplaces, to heat this building, even though each fireplace must be especially designed for its respective room, and I want first-class results in the way of ventilation, as well as heat. Therefore I would ask you, Mr. Sector, to give it more consideration and let me know your plans in a few days."

Theodolite N. Sector knew his client meant business, so he opened not his mouth further than to state that he would report in a few days. The two men parted. Mr. Abraham Goldberg, millionaire and monopolist, instantly threw aside the fireplace problem and strutted off to see the latest market quotations, while Mr. Sector thoughtfully wended his way to his office to worry out a solution.

Ordering the office boy to hunt up all circular matter pertaining to fireplaces, he spread out the floor plans of the building on the drafting table, run his fingers nervously through his long black hair, and pondered seriously until darkness overwhelmed him. When at length he roused himself from his study he found that the entire office force had gone and left him alone. Packing up the plans and circulars, he hurried home to get his supper and continue the study—a suicidal policy for mental workers. Poor fellow! he did not have the happy faculty of quitting business with business hours.

There was no jolly table talk at Sector's



"The chimney thus consisted of the entire house, and the people lived in the chimney."

home that night. The victuals went down, one after the other, in the order they came on the table, and with a rapidity that would have done justice to a New York down-town "quick luncher." A late supper eaten in that style is an elegant foundation for a nightmare, but poor Sector did not know it, for he thought of nothing but those open fireplaces.

While the family were still enjoying a cup of tea—just taken to keep him company, for

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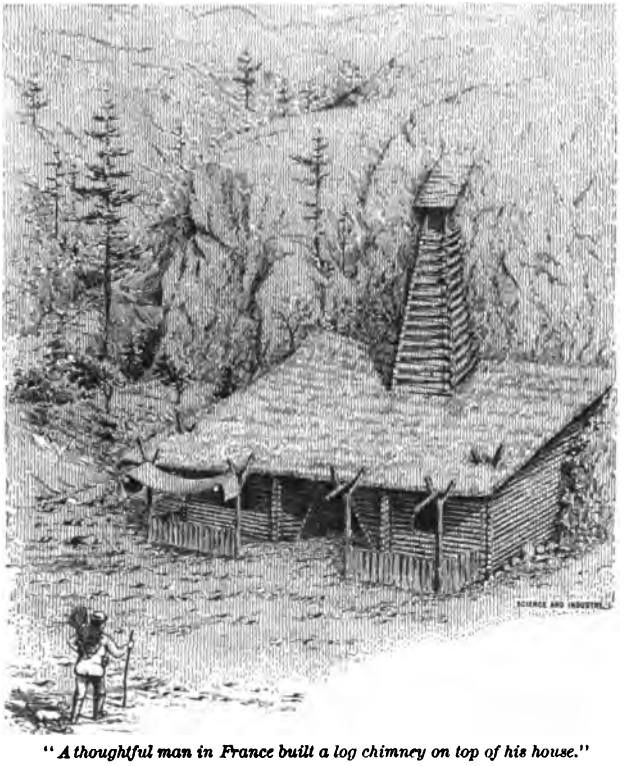
they had already partaken at the appointed time—he scurried off to his den like a hunted ground hog and pored over the plans and circulars again. He read Poker, Tongs & Co.'s catalogue through from cover to cover, but found no encouragement there, except a number of guarantees that he feared could not be fulfilled. Then he seized the massive circular of Andiron & Mantel, but found no relief there either, for it contained nothing but a lot of antiquated designs of mantels and open grates designed without any consideration for the heating of the rooms or the price of coal. Throwing away these works of advertising art in disgust, he grasped the neatly bound catalogue of The Modern Ventilating Grate Construction Co., as a drowning man clutches at a straw, and, turning his feet around to the fire, devoured the contents until his brain began to reel and the lines of print to teeter; the ventilating grates commenced to pile themselves on top of one another, and everything was confusion. Grates, mantels, pokers, tongs, hearths, chimney breasts, flues, registers, draft screens, and smoke jacks flitted and danced before him, separately and in combinations, each boasting its own peculiar merits, and all emphasizing their substantial guarantees, backed by references, recommendations, dollars, and wind. Then Goldberg loomed up like a yacht in a fog—smiling, as only Goldberg can when he is about to get what he covets—and with him came a friend, apparently a close friend; for he appeared to take a deep interest in the millionaire. He was tall, very tall and angular; his nose was not like Goldberg's—it was at least 80 per cent. longer; his cheek bones were high, and his chin pointed. It was a strong face, one calculated to hypnotize many people, and Goldberg evidently was influenced.



"A thoughtful man in France built a log chimney on top of his house."

"Ah, Mr. Sector," said Goldberg, expanding his smile, "I have been thinking about your difficulty since we parted, and I concluded that if any person can help you out it is my dear friend here, Prince Helios, Mr. Sector," and he bowed like a floor walker in Wanamaker's, while the Prince shook hands with the architect. "He has assisted me materially in many ways, and, if you will but give him your confidence, I am sure he can show you a solution to your problem," and Goldberg vanished as he came.

The Prince riveted his sharp piercing eyes on Sector, and the architect felt as helpless as a rabbit in the presence of a cobra—the eyes searched his inner man and the Prince knew him.

"By the way, Mr. Sector, it is meet that we should have a personal understanding and agreement before proceeding to discuss business. What remuneration would you be willing to give for a true solution of your problem?" asked the Prince, with an entirely changed visage.

"I would not care to go beyond 25 per cent. of my fees," replied Mr. Sector, talking in the way of the world again.

"But, my dear sir, gold and silver are of no use to me; I deal in nothing but mortgages. Suppose you give me a mortgage on

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your future life—say a 5-per-cent. mortgage on your soul? Read that slip over carefully, and, if satisfactory, you may sign it with this red ink," he said, as he handed them to Mr. Sector. The architect read:

PRINCE HELIOS' MORTGAGE.

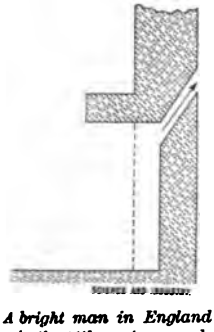
For services rendered, I ..... do hereby give and grant unto Prince Helios a ..... per-cent. mortgage on my soul and empower him to use it as he may see fit, but not to my worldly detriment.

This mortgage is redeemable any time before death.

Signed, ... (*Seal*)

Had it not been that Mr. Sector was in the presence of a man mentally mightier than he there would have been a disruption, for he boiled with fury, as architects often do about smaller things, but he calmed himself as best he could and simply said that he would rather throw up the whole job than consider such a proposition.

To his great surprise, the Prince shook his hand warmly, and congratulated him on his inward sincerity. "Stranger," said he, "you are the first business man I have met in the United States these last three months, who of his own free will and accord, refused to sign this document. You will never become wealthy, but you will live and die happy. I do a large business in your country," he continued, "and have a terrible name there, but it cannot be said that I ever forced, or in any way used my influence to induce any human being to sign my mortgages. I never advertise my business—my clients do it for me."



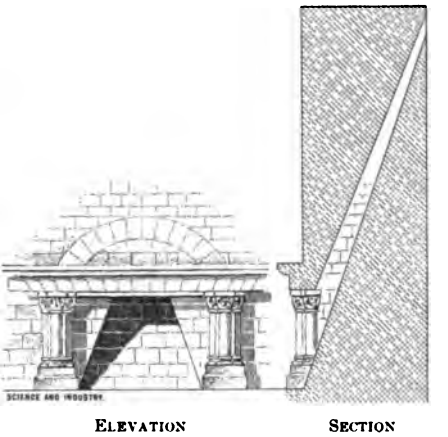
A bright man in England in the 11th century made this slanting hole, which authors call the origin of the chimney.

"Then I cannot expect you to help me out in my problem?" suggested our friend Sector.

"No, you cannot; my policy is to act honorably and fairly by my clients only. But Goldberg is one of them; I have a mortgage on 95 per cent. of him already, and I expect he will dispose of the remainder when he gets his bills for this new building you are designing. Besides, he is too rich ever to think of redeeming it. Therefore, he is a good client, and I will do *him* the service, using you as an instrument to accomplish the end."

"I understand you are well versed in fireplaces?" queried our friend with an impatient eye to business; "suppose you quote your experience for my client's good, and, perchance, my edification."

"Yes," replied the Prince, "I am well versed, for I have had entire control of a very large fire since the time that Adam—the scoundrel!—was chased out of the garden of Eden. My fire," he continued, "is a self-replenishing fire. In olden times I had to hustle for fuel, but fuel is plentiful nowadays, and it comes in of its own accord. The self-replenishing period began with the introduction of coinage, and the fond love of mortals for coin; but that does not interest you, since you will not sign the mortgage sheet.



ELEVATION SECTION

Fireplace in Conisborough Castle, showing flue in section. Built in the Anglo-Saxon period. The first flue to produce a draft on the fire.

"Many years ago when your forefathers first built houses, they built the fire on the ground and huddled around it for warmth. The smoke was allowed to diffuse with the atmosphere of the house, but most of it escaped through a hole in the apex of the roof. The chimney thus consisted of the entire house, and the people lived in the chimney. This arrangement, no doubt,

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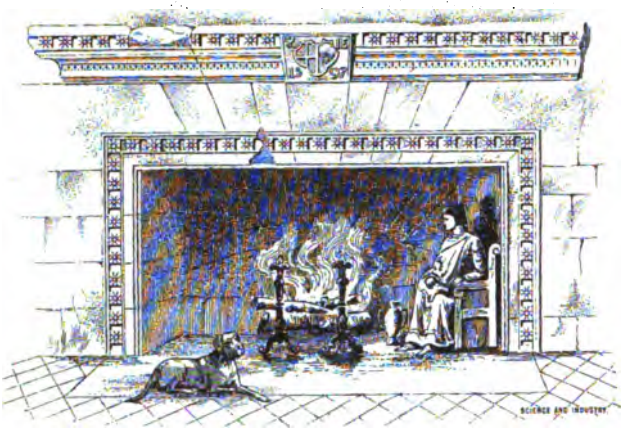
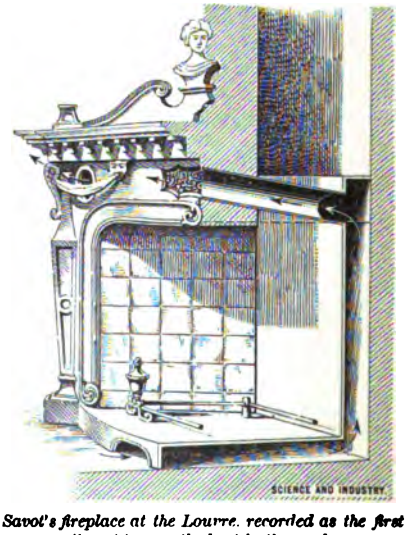


The fireplace in Roslyn Castle, of colossal dimensions, yet extremely simple in design.

appears barbarous nowadays, but so would modern fireplaces have appeared barbarous to the ancients had they but seen them. But the simple fire of the ancients had advantages that you should not lose sight of in designing or even selecting open fireplaces for my friend Goldberg's new house. For instance, the heat of the fire is utilized to a far greater extent than is accomplished by any of your up-to-date nonsense. All the radiated heat is employed in warming the inner walls of the house or hut, and everything in it, while the ascending smoke and products of combustion give off heat to the air by convection, and, last of all, the floor or ground is warmed by contact with the glowing fuel. From an efficiency point of view, the ancients were by far your superiors, for they, by their methods, utilized from 75 to 90 per cent. of the heat from their fuel, while you only utilize somewhere from 5 to 25 per cent. with your most gaudy open fires. As a ventilator, the primeval system is equal to or better than your modern systems, for impure air cannot remain in the room and the cold air entering is not drawn, so to speak, to a central spot limited by the height and breadth of the mantel. The drafts being less concentrated are consequently less dangerous. The only difficulty the ancients encountered was the smoke that would occasionally descend below the breathing line and make their eyes water. No doubt they could have improved their arrangement by constructing a central flue with sticks, smeared on the inside with mud or clay, and descending from the opening in the roof to a safe distance from the fire.

But they did not seem to think of a chimney for many years until a thoughtful man in France built a log chimney on top of his house. It took away the smoke, and heat, too. The years rolled on, and people became wise. A bright man in England in the 11th century removed his fire from the middle of the floor and placed it in a recess in the wall, and drove a slanting hole through the wall to let out the smoke. Some of your authors call this the *origin of the chimney*. But the wind blew in that hole as often as the smoke would go out of it, and mortals became wise and thoughtful again. It is believed by many that the first man to construct a flue was the architect that designed Conisborough Castle in or near the Anglo-Saxon period. This chimney is just an exaggeration of the original oblique hole in the wall, but it was carried through long enough to constitute what you now call a flue, and it produced a draft on the fire, which was more than any of the others could do. The Frenchman's chimney of logs could not produce a draft on the fire, for it did not run down below the roof.

"The form of flue in Conisborough Castle naturally led to the ordinary chimney as it



Savot's fireplace at the Louvre, recorded as the first attempt to save the heat in the smoke.

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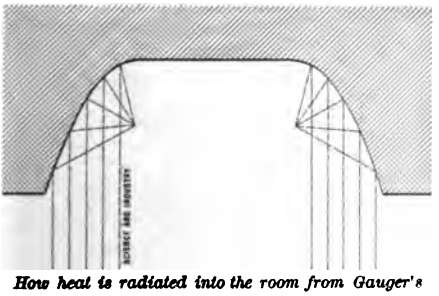
is now constructed. But the warlike folks of those times were prone to have large chimneys, and it is recorded that as late as 1712, a royal edict, proclaimed in France, fixed the sizes of chimney flues at not less than three feet wide, and deep enough to admit a chimney sweep.

"While doing business in some of the old English castles I have occasionally seen chimney flues eight feet wide by three feet deep. Of course, these large chimneys caused powerful currents of cold air to flow across the floor, and screens were necessary to break the draft. Yes, the fireplaces of the ancients were large. I remember the fireplace in Roslyn Castle well, for I sat in its ingle many a time when the old earl was alive. It was of colossal dimensions, although extremely simple in design. The fuel was trunks of trees cut to lengths of six or eight feet. Seats were placed all around the hearth, and sometimes inside the chimney breasts, and the screens and jambs of the fireplace formed a cosy enclosure—a complete antechamber, as it were—where the family would sit during the long winter evenings and talk over the famous legends of their noble ancestry.

"About the year 1600, a certain Louis Savot, a physician in Paris, made a study of the open fireplace, and his is the first recorded attempt to save the heat in the smoke. He built a fireplace at the Louvre and arranged it so that a current of air would pass under and around the back of the fire, where it would take up heat from partition plates and be discharged into the room above the level of the fireplace opening. This was the beginning of the period of warming rooms by convection from open fireplaces built in the side walls. Since then



How heat is radiated into the room from Gauger's fireplace.

many patents have been granted for the selfsame thing and the patentees do not seem to know that Mr. Savot was ahead of them at least 200 years.

"Savot's was not a ventilating grate, for it took its air supply from above the floor and circulated it in the room. But in the year 1713, one Gauger (I forget whether he

Rear view of the "Modern" ventilating grate, showing smoke flues and heating surfaces.

was an English mister or a French monsieur) really invented the ventilating grate, at least so it is recorded. The ideas of two other men were combined and this produced a real ventilating grate, which is father to all ventilating-grate patents of today. He produced an open fireplace with hollow back, jambs, hearth, and mantel, and furnished with a tube connection to the outer atmosphere, from under the hearth, and a grilled opening into the room at the mantel. Parabolic jambs were also provided, for Gauger reasoned with the great geometricians of old that 'all radii that set out from the focus of a parabola and fall upon its sides are reflected back parallel to its axis.' There you will see that in Gauger's fireplace all rays impinging on the curved jambs are radiated forward into the room in imaginary parallel lines. And the plate under the mantel was curved or splayed, which had the effect of throwing the heat rays on the floor where they were most required—all of which was a great improvement on the old square-jamb fireplace whose rays were thrown from jamb to jamb, and from mantel soffit to hearth.

"But, although Gauger's invention projected radiant heat into the room, and although some of the heat in the smoke and gases of combustion was utilized to warm the room, it nevertheless was a heat waster, for most of the heat went up the chimney with the smoke.

"The years rolled along and many changes were made in open fireplaces. Some were improvements and others were not. The improvements were made chiefly along the

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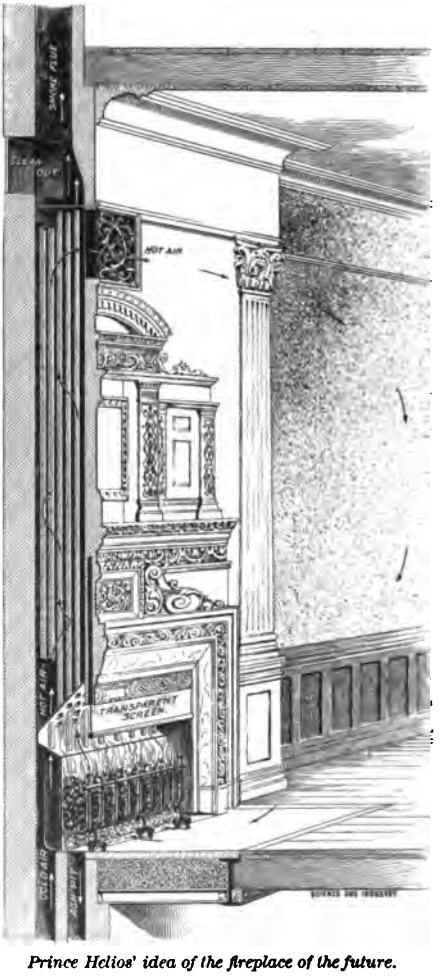
line of efficiency by increasing the amount of heating surface over which the heated smoke and gases had to pass. If you look over your catalogues you will notice this in the

The "Modern" ventilating grate set up in place.

'Modern' ventilating grate. The increased surface is obtained by making a series of small flues, which break up the main current of heated gases and cause them to part with their heat more rapidly; also by providing pins or other projections at the back of the iron plate. These form 'extended' surfaces against which the air may impinge. An excellent example is shown by that rear view of the 'Modern' ventilating grate. The smoke from the fire passes up through the four oblong openings shown on top. And the fresh air travels up over the heating surfaces in the direction of the fins and the flues, and is discharged into the room through a grille located over the fireplace and immediately in front of the oblong flues. You can see this to better advantage in the cut that illustrates the ventilating grate set up in place. The tile hearth, the fender, the grate, the mantel, the chimney, and the trimmer arch are all shown so clearly that the cut really explains itself. Under the ash-pit you will notice a large hole in the chimney with a damper over it. This is to receive ashes and thus prevent dust from entering the room when ashes are removed. This is a good idea, and quite creditable even for the 19th century. Then, again, you will observe that a hot-air pipe is continued up the smoke flue, a damper being located at its base that may be operated by a rod extending through the grille previously mentioned. This hot-air pipe may be run up to the room above and the hot air allowed to discharge there, if so desired, or it may terminate at the ceiling of the room in which the grate is located, if it is a large or very cold room. The advantage of running the pipe in the flue is that it will absorb heat from the smoke in the flue that would otherwise be lost. There is a damper, not shown in the cut, that closes over the oblong smoke vents to regulate the draft.

"I believe this represents the most efficient form of open-fire arrangement on the market today, and it gives first-class results



Prince Helios' idea of the fireplace of the future.

in the average building. You cannot very well heat Goldberg's largest rooms with these, however, and if he persists in having nothing but open fires, you had better have

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some special designs made, and build your chimneys to suit the improved apparatus. The improvements you make must be in the way of extracting all the heat possible from the smoke and chimney gases. You can do this easily by continuing small smoke flues up the chimney to a point a few feet below the ceiling. This will make an elegant economizer. Let me suggest an idea based on my long experience, but do not attempt to patent it or I will be compelled to claim priority through one of my subjects. If properly considered by architects and manufacturers, it will become the fire of the future. Build a grate similar to the 'Modern' grate and set it in the same way, but break up the flue into a series of flues 2 inches in diameter, by means of iron pipes. Secure the ends of these pipes to cast-iron plates, one at the top, just over a wall register, near the ceiling, and the other just over the fire in the grate. Provide a secret access hole at the base of the main chimney flue and near the ceiling. Hinge a neatly paneled board over the mantel for access to the tubes, making this air-tight, just like an ice-chest door. Arrange your fresh-air duct to supply the space around the tubes with cold air; arrange an ash-pit chute under the grate and in a general way make it like this (see accompanying figure). But you must extend the brickwork of the fireplace full width up to the ceiling, and there you may throat in to a common flue. You require all that space for a proper economizer, such as the 2-inch tubes would surely be. Now design an arrangement like this, send the drawings to the 'Modern' people, and let them make them. Build your chimneys to receive them, so that the 'Modern' people can ship the apparatus in one piece, like a return-tubular boiler, all tested, gas-tight, and ready to set up in place like a square tubular pillar with an open grate for a base and an ornamental register for its capital. Then you may finish over the face of the chimney with all the ornamentation and deceptive art that your 19th century architects are noted for.

"I would recommend the use of a special glass screen to pull up and down in front of the fire for the purpose of making or breaking the draft, and thus regulating the rate of combustion of fuel without hiding the flames altogether. With this arrangement, I warrant, you will be able to roast Goldberg easily, if necessary, even when the mercury is below zero out doors.

"But, before we part," continued the the Prince, "come and see my fire; you may gain some points"; and suddenly Mr. Sector was standing on the brink of a terrible precipice looking down on a flaming gorge below. The efficiency of that fire was so perfect that the heat was retained below. But the fuel was human beings. Sector recognized some of them and he trembled for his own safety. The ground he stood on was slipping from under him. He could not run. Turning suddenly to implore help from the Prince, he saw that the reflection had turned him red and hideous, and the legendary horns became visible. He was falling—down, down, down—but he woke before he got to the bottom, and found it was all a dream. His faithful wife, who all the time had been sitting by his side, thinking that the sleep would rest his weary brain, now stood over him with a fan, alarmed at his terrible awakening and in total ignorance of the noble part her husband had taken in the battle of his dreams. But Sector got valuable ideas, and he used them to advantage in Mr. Goldberg's new house.

HOW WE DO IT TODAY

"In olden times we took a car
Drawn by a horse, if going far,
And felt that we were blest;
Now the conductor takes the fare
And sticks a broomstick in the air
And lightning does the rest.

"In other days, along the street,
A glimmering lantern led the feet
When on a midnight stroll;
But now we catch, when night is nigh,
A piece of lightning from the sky
And stick it on a pole.

"Time was when one must hold his ear
Close to a whispering voice to hear,
Like deaf men—nigh and nigher;
But now from town to town he talks
And puts his nose into a box
And whispers through a wire."

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MOTION IN GEAR-TRAINS

G. A. Goodenough

VELOCITY RATIOS IN EPICYCLIC TRAINS—CONSTRUCTIONS FOR DETERMINING INSTANTANEOUS CENTERS—THE BEVEL-GEAR TRAIN

GEAR-TRAINS, especially epicyclic gear-trains, furnish good examples of the applicability of instantaneous centers in the analysis of motion. We have pointed out in a preceding article that the instantaneous-center method, while straightforward and perfectly general, is difficult to apply when the mechanism has a large number of links, simply because it is usually necessary to locate a large number of these centers. In such mechanisms, therefore, the velocity polygon furnishes a far simpler and easier means of studying their motions. On the other hand, mechanisms that contain gear-trains or cam-trains have their instantaneous centers accessible and easily located; and, though in simple cases the motion may be analyzed from elementary considerations, it will in all cases prove helpful to use these centers, if only as a check on the results arrived at by other methods.

As a simple example of the use of instantaneous centers, let us take a pair of circular spur gears, as shown in Fig. 1. If two axes are stationary, the problem of finding the relative number of revolutions of the two wheels is ridiculously simple. Any one at all acquainted with the operation of mechanisms will at once say that the numbers of revolutions are inversely proportional to the radii, the diameters, or the number of teeth of the two wheels; thus, if the diameter of the wheel a is double that of b, then b will make twice as many revolutions per minute as a. For the sake of completeness, however, we give the formal proof of this law.

Let the fixed axes be indicated by E and F, and the point of contact of the two wheels by G; and let W_a and W_b denote, respectively, the angular velocities of the wheels a and b. As we have explained in a previous article, the *linear* velocity of any point in a body is the product of the *angular* velocity of the body and the distance of the point from the center of rotation. Further, the number of revolutions made in a given time is proportional to, or rather is a measure of, the angular velocity. Thus, if the wheel b makes double the number of revolutions of the wheel a in the same time, it is evident that a radius on b sweeps over a given angle, say 360°, in one-half the time that a radius on a does; or, in other words, the radius of b sweeps over double the angle of the radius of a in the same time. These preliminary explanations are necessary to render clear the reasoning that follows.

From the well-known action of gear-wheels, the points of the two pitch circles that are in contact have exactly the same linear velocity; in fact, any point on the pitch circle of b must have the same linear velocity as a point on the pitch circle of a. Let us denote this linear velocity by V; then, considering G as a point of the wheel a,

$$V = W_a \times EG;$$

that is, linear velocity of G = angular velocity of $a \times$ distance of G from center E. Considering G a point on the wheel b,

$$V = W_b \times FG.$$

Hence, $W_a \times EG = W_b \times FG$;

or,
$$\frac{W_b}{W_a} = \frac{EG}{FG} = \frac{R}{r}, \quad (1)$$

where R and r denote, respectively, the radii of the wheels a and b. Expressed in words, *the angular velocities—and therefore the revolutions per minute—vary inversely as the radii of the gears.*

Suppose, now, that the wheel a is fixed and the arm m, carrying the wheel b with it, rotates about the fixed center E. During this motion the wheel b revolves on its axis F, and the question to be investigated is the relative motion of the wheel b and the arm m; that

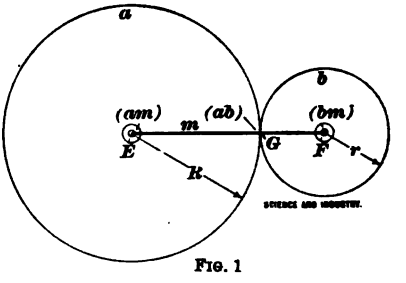

FIG. 1

is, we wish to find the number of revolutions of b to one revolution of the arm m. The solution to this problem is very similar to the solution given above, and is in every respect as simple and easy; yet we venture

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to assert that most of the readers of this article, unless they have previously been brought face to face with the problem, will find themselves somewhat puzzled to arrive at the correct solution. Let us attack the problem by finding the instantaneous centers.

The center of the motion of m relative to a is the axis E; this we denote by $(a\,m)$. The center of the motion of b relative to m is evidently the axis F. These centers are, of course, permanent. Since the pitch circle of b rolls on that of a, the point of contact of a and b, the point $(a\,b)$, or G, must be the instantaneous center of this motion. As a is at rest, the point of b in contact with a must be the one point of the wheel b that is at rest; that is, the point about which b is for the instant rotating. The point F, or $(b\,m)$, is common to b and m. If we denote by V the velocity of F, and by W_m the angular velocity of m, then considering F a point of m, we have

$$V = W_m \times EF.$$

But, since for the instant the wheel b is rotating about G as a center, if we consider F a point of b, its velocity is given by the expression

$$V = W_b \times FG.$$

Hence, $$W_m \times EF = W_b \times FG;$$

or, $$\frac{W_b}{W_m} = \frac{EF}{FG} = \frac{R+r}{r} = \frac{R}{r} + 1. \quad (2)$$

This result is very instructive. Referring to Fig. 1, it is seen that the rotation of the wheel b has the same sense as that of the arm m; that is, if m moves in the same sense as the hands of a clock (clockwise), a radius of b will also move in a clockwise sense. Suppose that b is disengaged from a so that it has no motion relative to m; then, if m makes one revolution about E as a center, carrying b with it, b must at the same time make one revolution. If b is engaged with a, it will make $\frac{R}{r}$ revolutions to one revolution of a, as shown by formula (1). Hence, when b is carried by m and is at the same time engaged with a, it makes $\frac{R}{r} + 1$ revolutions for each revolution of m, the $\frac{R}{r}$ revolutions being due to the contact between a and b, and the one revolution to the one revolution of the arm m. The two are added, since, as we have seen, they have the same sense.

Suppose, now, that we have the case shown in Fig. 2, in which the wheel a is annular, the point of contact G being on the inside. As before,

$$\frac{W_b}{W_m} = \frac{EF}{FG}.$$

But, $$EF = EG - FG = R - r;$$

hence, $$\frac{W_b}{W_m} = \frac{R-r}{r} = \frac{R}{r} - 1; \quad (3)$$

that is, if m makes one revolution, b will make in the meantime $\frac{R}{r} - 1$ revolutions. Whether W_b and W_m have the same sense or opposite senses is easily determined as follows: In both Figs. 1 and 2, the point F is common to b and m; as a point of b, F is rotating about G, and as a point of m, it is rotating about E. Now, in Fig. 1, the two centers of rotation G and E are on the *same* side of the common point F, and it is evident that in consequence the bodies m and b must rotate in the same sense; this we have already pointed out. In Fig. 2, on the other hand, E and G are on *opposite* sides of F, consequently, the sense of the rotation of b is opposite to that of m; that is, if the rotation of m is clockwise, that of b is counter-clockwise, and vice versa.

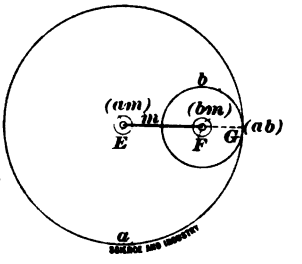

FIG. 2

In Fig. 3 is shown the case of a fixed gear a and an arm m carrying the wheel b and an idle wheel c. The instantaneous centers (am), (ac), (cm), (bc), and (bm) are readily located as shown in the figure. As we are investigating the motion of the wheel b, we require the sixth center $(a\,b)$. In this case the ordinary method of finding the center by the intersection of two lines fails, because the five known centers all lie in one line. We may, however, overcome this difficulty as follows: It is evident that the motion of b depends merely on the relative diameters of a, b, and c, or upon the relative numbers of teeth in a, b, and c (we shall see presently that the size of c has no influence on the relative motion of a and b); hence, we may place b in some other position, say b' on the circumference of c. The point of tangency of b' and c is the instantaneous center $(b'c)$, and a line through this center and the center $(a\,c)$ must contain the desired instantaneous center $(a\,b')$. The point F', at which b' is pivoted to the arm m, is, of course, the center $(b'\,m)$;

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hence, a line through this point and the center $(a\,m)$ must also contain $(a\,b')$. The intersection G' of these two lines is the center $(a\,b')$.

We can now find the relative angular

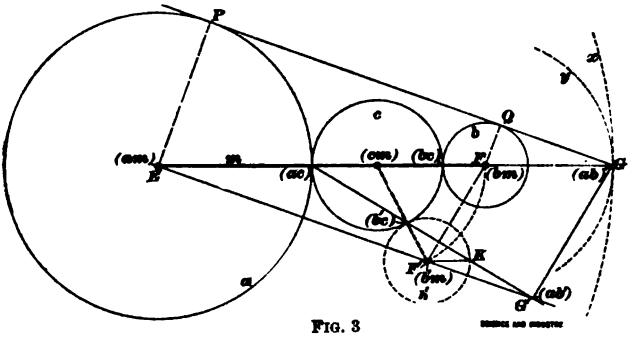

FIG. 3

velocities of the arm m and the wheel b'. The point $(b'm)$ has the same velocity whether considered as a point of b' or as a point of m; let us call this velocity V. Now the arm m is rotating about the point $(a\,m)$ with an angular velocity W_m; hence, $V = W_m \times E\,F'$. At the instant under consideration, the wheel b' is rotating about the instantaneous center $(a\,b')$ with an angular velocity W_b; hence, $V = W_b \times F'\,G'$. Placing the right-hand members equal, we have,

$$W_b \times F'G' = W_m \times E\,F';$$

or,
$$\frac{W_b}{W_m} = \frac{E\,F'}{F'\,G'}.$$

Let us join F' and F and through G' draw a line parallel to $F'F$, cutting $E\,F$ produced in G; then, from the similar triangles $E\,F\,F'$ and $E\,G\,G'$, we have the proportion:

$$\frac{E\,F'}{F'\,G'} = \frac{E\,F}{F\,G}.$$

But $\frac{E\,F'}{F'\,G'} = \frac{W_b}{W_m}$; hence, $\frac{E\,F}{F\,G} = \frac{W_b}{W_m}$, and it follows from this that G must be the instantaneous center $(a\,b)$ that was sought originally.

Denoting by R and r the radii of the wheels a and b, it can readily be shown that the following proportions hold good:

$$\frac{R}{r} = \frac{E\,G'}{F'\,G'} = \frac{E\,G}{F\,G}.$$

The proof is as follows: Join F' to the point K in which the line $(a\,c)\,G'$ cuts the circle b'; then, since $F'K$ and $F'\,(b'c)$ are radii of b', they are equal, the triangle $F'\,(b'c)\,K$ is isosceles, and the angle $F'\,K\,(b'c)$ is equal to the angle $F'\,(b'c)\,K$. Similarly, the triangle $(b'c)(c\,m)(a\,c)$ is isosceles and its acute angles are equal, and, moreover, they are equal to the acute angles of the triangle $F'\,(b'c)\,K$. Since, now, the acute angle at $(a\,c)$ is equal to the acute angle at K, $F'K$ is parallel to $E\,F$, and, in consequence, the triangles $G'\,(a\,c)\,E$ and $G'\,K\,F'$ are similar; hence the proportion,

$$\frac{E\,G'}{F'\,G'} = \frac{E\,(a\,c)}{F'\,K} = \frac{R}{r}.$$

Having proved that this proportion exists, we may derive from it an easy construction for finding the center $(a\,b)$. Let a line $P\,Q$ be drawn tangent to the circles a and b. If P and Q are the points of tangency, the radii $E\,P$ and $F\,Q$ are parallel. Let G be the intersection of the tangent with the line of centers $E\,G$; then, since the triangles $G\,E\,P$ and $G\,F\,Q$ are similar, we have

$$\frac{E\,G}{F\,G} = \frac{E\,P}{F\,Q} = \frac{R}{r}.$$

From this it follows that the intersection b of the tangent with the line of centers is the desired instantaneous center $(a\,b)$. Since,

$$\frac{E\,G}{F\,G} = \frac{E\,F + F\,G}{F\,G} = \frac{E\,F}{F\,G} + \frac{F\,G}{F\,G} = \frac{W_b}{W_m} + 1,$$

and since
$$\frac{E\,G}{F\,G} = \frac{R}{r},$$

we have
$$\frac{W_b}{W_m} + 1 = \frac{R}{r};$$

or,
$$\frac{W_b}{W_m} = \frac{R}{r} - 1. \qquad (4)$$

From formula (4) we deduce at once two important facts:

1. The ratio of the angular velocities of the wheel b to that of the arm m depends

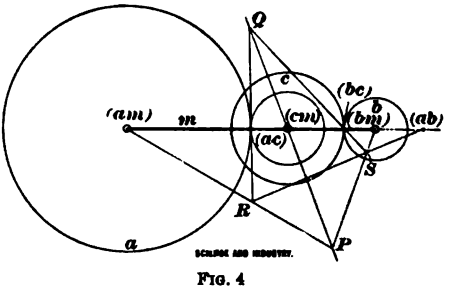

FIG. 4

only on the ratio of the radii of a and b, and not at all on the radius of the wheel c; for this reason c is called an *idle* wheel.

2. Since formula (4) is identical with

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formula (3), the motion of b relative to a and m is precisely the same as in the annular arrangement, Fig. 2, provided the ratio $\frac{R}{r}$ is the same in the two cases. Thus, we can replace the arrangement in Fig. 3 by an annular gear with center at E and pitch circle x passing through $(a\,b)$, or G, and a spur gear with center at F and a pitch circle y also passing through $(a\,b)$. Since the three centers $(a\,m)$, $(b\,m)$, and $(a\,b)$ are the same in the second arrangement as in the first, the relative motions of the three links, a, b, and m are precisely the same in the two cases.

In Fig. 3, as in Fig. 2, the centers $(a\,m)$ and $(a\,b)$ are on opposite sides of the center $(b\,m)$; hence, the rotation of b has a sense opposite to that of the rotation of a.

The gear-train shown in Fig. 4 differs from that shown in Fig. 3 in having an intermediate wheel with two pitch circles of different radii, one in contact with a and the other with b. In this case, the ratio of the two radii of c exerts an influence on the motion of b, and the instantaneous center $(a\,b)$ of the motion of b relative to a is *not*, as in Fig. 3, on the common tangent to a and b. All the instantaneous centers being in the same line, we may, as in Fig. 3, place the wheel b in a different position on the circumference of c and repeat the construction of Fig. 3 to find the center $(a\,b)$. A more elegant method, however, is that shown in Fig. 4. Through the center $(c\,m)$ any line is drawn and on it any two points P and Q are chosen. P is joined to $(a\,m)$ and $(b\,m)$ and Q is joined to $(a\,c)$ and $(b\,c)$, the latter lines being prolonged to meet those through P in R and S, respectively. Then a line through R and S cuts the line of centers in the desired point $(a\,b)$.

The proof of the construction given is too long for insertion here but may be found in standard works on kinematics. The construction of Fig. 3 is in reality a special case of this more general construction. The center $(a\,b)$ being known, the relative motions of the links a, b, and m are readily found from the relative positions of the centers $(a\,m)$, $(b\,m)$, and $(a\,b)$.

So far we have considered gear-trains with motion in one plane only. As a closing example we shall consider a case in which the motions are not in one plane and in which, as a consequence, instantaneous axes instead of instantaneous centers must be used. In the bevel-gear train shown in Fig. 5, the wheel a is fixed or stationary, while the wheel b rotates about its axis $O\,Y$. Between the two is a third bevel wheel c that may turn on it axis $O\,Z$, while this axis itself rotates about the point O, as shown in the lower view. The wheels a and b have the same pitch diameter; the diameter of c is of no consequence. The problem is to determine the relative motion of the wheel b and the axis $O\,Z$; that is, to determine the ratio of the revolutions made by b to the number made by $O\,Z$ in the same time.

The pitch cone of c is rolling on that of a, the line of contact of the two cones being $O\,X$. This line is the instantaneous axis of the motion of c relative to a, or it is the axis about which the body c is for the instant rotating. Hence, the linear velocities of different points of c are proportional to their respective distances from this axis $O\,X$. Suppose $Q\,R$ to be the diameter of the mean pitch circle of the wheel c, and P to be the center of that circle. Then

$$Q\,R = 2\,P\,R$$

and

$$Q\,O = 2\,P\,S,$$

$Q\,O$ and $P\,S$ being, respectively, the perpendicular distances of Q and P from $O\,X$. Since Q is twice as far from $O\,X$ as is P, the linear velocity of Q is double that of P; denoting these velocities by V_q and V_p, respectively, $V_q = 2\,V_p$. But the linear velocity of Q is the same as that of the point on the wheel b with which it is in contact. In other words, Q may be considered as a point of c or as a point of b, and has the same velocity in either case. The perpendicular distance of Q from the axis $O\,Y$ is $Q\,T$; hence, if we denote by W_b the angular velocity of b about its axis $O\,Y$, we have

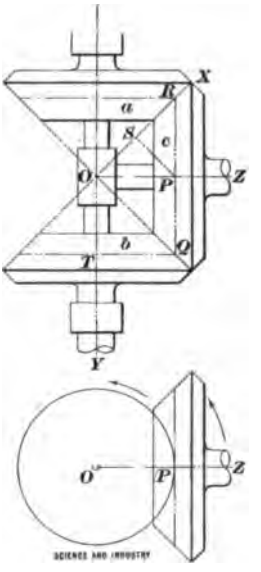

FIG. 5

$$V_q = W_b \times Q\,T.$$

Now, P is a point in the axis $O\,Z$, and, as such, is describing a circle of radius $O\,P$ about the center O. If, then, we denote by W_p the angular velocity of P, or what is the

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same thing, the angular velocity of the axis OZ, we have

$$V_p = W_p \times OP.$$

But, since $OP = QT$, we have by division

$$\frac{V_q}{V_p} = \frac{W_b}{W_p} = 2.$$

In words, the wheel b makes two revolutions about its axis OY while the axis OZ turns once around the point O. This result is independent of the diameter of c. It may be pointed out that with this train the angular motion of the axis of c is always a mean of the angular motions of a and b. Thus we may have any of the following combinations:

Rev. of a	Rev. of OZ	Rev. of b
0	n	$2n$
$-n$	0	$+n$
n	$\frac{n+m}{2}$	m
n	$\frac{n-m}{2}$	$-m$

THE GALVANOMETER

James E. Boyd

USE OF CONTROLLING MAGNET — ASTATIC GALVANOMETER WITH CONTROLLING MAGNET. FOUR-COIL REFLECTING GALVANOMETER—SETTING UP GALVANOMETERS

IN ADDITION to the astatic needle there is another device for increasing the sensitiveness of a galvanometer needle. This is by using a permanent magnet to weaken the earth's field.

If NS, Fig. 2, is a bar magnet, its lines of force run out at N and return at S. At c, directly below the middle of the magnet, they run parallel to it. Suppose that this magnet is placed horizontal, with its N pole pointing toward the north. At c its lines run from north to south, opposite those of the earth. If the earth's field is .2 dyne, and that of the magnet at c is .19 dyne, we have as a result .01 dyne, so that a galvanometer with its needle at c will have its sensitiveness made twenty times as great by bringing the bar magnet to this position. If the needle is raised to c', it is brought into a position where the field of the magnet is greater than that of the earth, and will turn around with its N pole pointing toward the south.

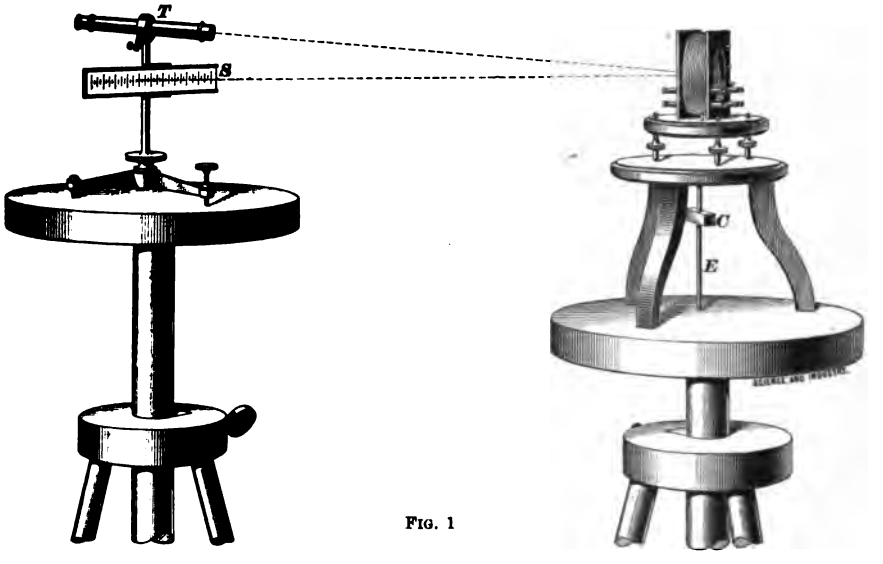

FIG. 1

This bar magnet may be straight, as C, Fig. 1. It is usually placed on a vertical rod, such as E, Fig. 1, and r, Fig. 4. It may

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be pushed up and down along this rod so as to vary the force at the galvanometer needle and be turned about the rod as an axis so as to change the direction in which the needle points. As it is used to change the direction of the resultant force, it is called a *directing magnet*. Home-made instruments may often be made more sensitive by placing a bar magnet near them. Set the galvanometer needle in vibration and notice the time required for it to swing back and forth. Now bring up your bar magnet and again take the time of vibration. If the needle swings slower, the sensitiveness has been improved by the magnet; if the time of vibration is doubled, the instrument is four times as sensitive.

The most sensitive galvanometers are astatic and have directing magnets. In Fig. 3 we have such an instrument, with the case and directing magnet removed. There are four coils, one of which, *a*, has been opened out to show the upper set of magnets *m*. One set of magnets hangs in the hollow between the coils *a* and *b*; while the other set is between *c* and a fourth coil back of it. These magnets and the mirror are supported on a light aluminum rod *r*, hung by a quartz or silk fiber to *g*. Instead of a needle system made of a single pair of magnets, there are two sets of four each. These are very light and are stronger than a single magnet of the same length and weight. The upper four magnets have their poles in one direction, and the lower four in the opposite direction. The coils are so connected that the current

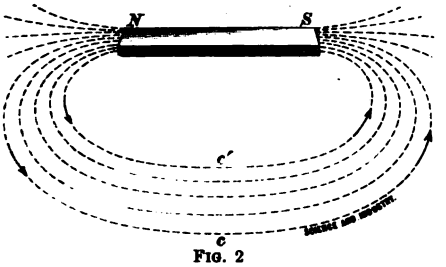

FIG. 2

flows in opposite directions in the upper and lower pairs. A light mica vane *v* is attached to the mirror. This, in swinging through the air, dampens the vibrations and quickly brings the needle to rest. There are four binding posts on this instrument, arranged so that the coils may be used in series or in parallel. This galvanometer has no pointer, but makes use of a beam of light reflected from

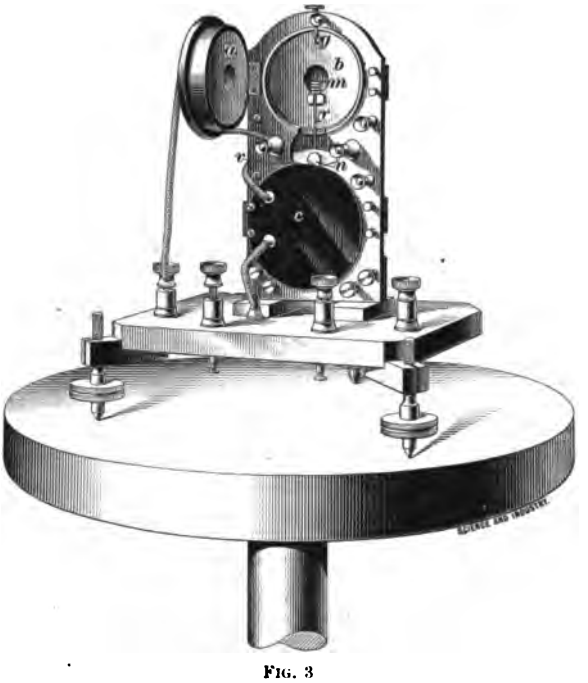

FIG. 3

the mirror *n*. As we know, when a mirror is rotated through a given angle, the reflection will move through twice that angle; so that with a beam of light, we not only have a pointer of no weight but one that multiplies our deflections by two. The method of using a mirror is shown in Fig. 4. A beam of light from a source to the right is reflected by a mirror, the back of which is shown at *o*, through the opening *a* to the galvanometer mirror *c*; from the galvanometer it is reflected back to *e*. The point *e* is on a translucent scale made of oiled paper or ground glass; the light at *e* strikes on the side opposite the observer and shows through. A piece of white paper might be used, in which case the observer must stand on the side toward the galvanometer. In this case, the galvanometer mirror is concave, and it is placed at such a distance from the scale as to give a real image of *a* upon it. The least motion of the mirror is shown by a movement of the light upon the scale. Unless the light thrown on the mirror is quite strong, the instrument must be used in a partially darkened room.

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Another method of using a mirror galvanometer is shown in Fig. 1. Here we have a paper scale S attached to a stand that also carries a small telescope T. The telescope is pointed toward the galvanometer mirror and focused so that the reflection of the scale may be seen. When the galvanometer mirror moves, the scale seems to travel across the field of the telescope, and the exact amount of this motion may be accurately determined. Very good work may be done without the telescope. A pin or wire may be set up above the scale, to be used as a point of reference, and the observer may look past that to the reflection of the scale.

FIG. 4

In using a Wheatstone or slide-wire bridge, we only wish to know whether the galvanometer is deflected, and do not care how great the deflection is (except for very close work). In this case, a mirror galvanometer may be used without any telescope and scale. Place a pin or a lamp or any other bright object in such a position that its reflection may be seen in the galvanometer mirror. Then, on closing the key of your bridge, it will be easy to see whether this reflection moves, and in what direction.

In setting up a mirror galvanometer, the base must first be set approximately level. The instrument shown in Fig. 3 has a level attached, but most instruments have not. Then, if it is not already in position, the needles must be raised to the proper height. This is done, as in Fig. 3, by pulling up on the pin g. There is a thin strip of brass in front of this pin, which is adjusted by means of a screw, so as to vary the pressure on the pin, and consequently change the force required to move it. In Fig. 4, this pin may be reached by removing the long thumbscrews h and f and lifting off the piece g that supports the directing magnet. By looking through at the galvanometer needle you can readily see when it is at the center of its opening. If it hangs at one side of the opening, the instrument must be leveled to bring it to the center. If it does not swing free, it is probably touching at the front or back, and a slight change of the back leveling screw should set it free.

When the needle is set in vibration it should swing evenly, and each time come to rest at the same point. Frequently there is a short piece of fiber where the needle is supported, and this rubs against the walls of the instrument; or, anywhere along its length there may be a small piece of fiber that touches against the coil. The needle may vibrate, but its zero point is apt to change erratically. Great care must be taken with such galvanometers so as not to bend the aluminum rod that supports the needles, since it is impossible to adjust the instrument unless this hangs vertically.

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JET PROPULSION

John A. Grening

DIFFERENT MEANS OF PROPULSION—CAUSES OF FAILURE OF DIFFERENT SYSTEMS OF JET PROPULSION—THE MOST ECONOMICAL PROPELLING INSTRUMENT

THE daily press contains frequent accounts of recently invented vessels that, by utilizing some method of propulsion different from that usually applied, will attain abnormal speeds at a very small expenditure of power. Needless to say, very few of these vessels get beyond the "newspaper-account" stage; but, once in a while, the inventor actually succeeds in interesting capitalists, with more money than brains, in his revolutionizing invention, and a boat, or even a larger vessel, is actually built. A trial, however, almost invariably proves that the new method that was to revolutionize ocean travel is, to say the least, a howling failure. It need scarcely be stated that none of these inventions is made by naval architects or naval engineers; they usually emanate from the brain of some member of the other learned professions, who, by virtue of a somewhat protracted education in dead languages and a special education in law or medicine, fondly imagines himself better able to harness the forces of nature than the mechanical engineer.

Very few of these epoch-making, revolutionizing, wonderful, and grand discoveries—terms by which the versatile Sunday newspaper reporter usually describes the latest scheme—would go beyond the conceptive stage if the inventor of the aforesaid scheme were able to distinguish between force, work, energy, and power, and understood the elementary principles of propulsion of vessels. Only a very few years ago a doctor of Brooklyn, N. Y., succeeded in demonstrating—to the tune of a sum that report has placed at $300,000—that his ability in curing diseases did not enable him to design a more perfect system of propulsion than is in common use. As the failure of the large vessel he had constructed was primarily due to misconception and misconstruction of the most elementary principles of mechanics, the lesson to be drawn from this failure is obvious. More recently, a disciple of Blackstone, located in Toronto, has, by the stupendous failure of his invention, again emphasized the lesson to be drawn from the failures of his predecessors. The frequency with which new systems of propulsion are reported in the daily press indicates that quite a large number of persons are chasing a will-o'-the-wisp, owing to insufficient elementary knowledge. Hence, it is believed that a short exposition of the principles involved in propelling a vessel will prove of interest.

Broadly speaking, a vessel may be propelled by internal or external means. In a vessel propelled by external means, the wind acting against sails is the propelling agent. This method of propulsion is beyond the scope of this article, which will deal entirely with self-propulsion; that is, propulsion by internal means.

There are two methods of self-propulsion: by the reaction of a stream of water, caused by suitable means to flow in a direction opposite to that in which the vessel is to move; and by pulling the vessel along a chain by suitable machinery. This latter method is occasionally employed for short trips by ferry boats and similar craft. An example of this method of propulsion is to be found in the Brooklyn navy yard in the ferry boat running between the Cob dock and the mainland. The other method of propulsion is the one in common use. A stream of water is projected from the vessel by a screw propeller, paddle wheel or wheels, or a pump. This stream of water, by its reaction, propels the vessel.

Judging by the numerous newspaper accounts, very few inventors attempt to improve the action of the screw propeller or paddle wheel. To deter would-be inventors, it may be stated that the efficiency of the screw propeller or paddle wheel in ordinary work is as high as 85 per cent., and in good work considerably higher. It is thus seen that there is only a small margin left for improvement, and that doubling the efficiency, and other similar claims made for fanciful designs of propellers, are caused by lack of knowledge. From this it must not be inferred, however, that the propeller, as fitted, is always perfection, and cannot in any case be replaced by one giving better results. Furthermore, the term *efficiency of the propeller* must not be confounded with *efficiency of the propelling apparatus*. The

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latter term refers to the combined efficiency of the propeller and its actuating mechanism.

The great majority of the attempted improvements were made along the lines of substituting a pump for the wheel or screw propeller. While this is an entirely feasible method of propulsion, it is in its application that the greatest and costliest mistakes have

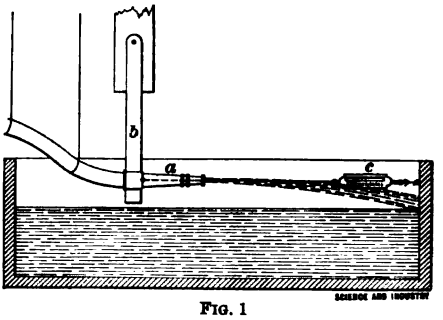

FIG. 1

been made by amateur designers—mistakes due solely to lack of elementary knowledge. Two of the favorite claims of inventors of new systems of jet propulsion are as follows:

1. That a stream of water, issuing from a nozzle under water, reacts on the surrounding water, and tends to drive the nozzle in the opposite direction in the same way that a solid rod issuing from the same nozzle would react on a stone wall.

2. That projecting a small stream at a high velocity is exactly the same thing as projecting a large stream at a low velocity, and, consequently, they can use small, fast-running machinery of light weight, besides getting rid of what is claimed to be complicated machinery used in screw and paddle-wheel propulsion.

Both of these claims are fallacious, and any system of jet propulsion based on either or both must prove a disappointing failure, as the claims are not in accordance with the laws of nature. Taking up the first claim, it is an indisputable fact that it is entirely immaterial whether a stream of water is projected into the water surrounding it, against a solid object, or into the air; if the stream and its velocity are equal in all cases, the reactions will be equal. Failure to understand this proposition caused the costly failure of the vessel designed by the doctor previously mentioned, because his whole design was based on the hypothesis that the reaction of the projected stream would be much greater under water than it was in air.

In order to disprove this statement, Mr. Charles J. Everett, in the beginning of 1891, rigged up a very simple apparatus to prove that the reaction was entirely independent of the medium into which the jet was discharged. This apparatus was described in a paper read before the American Society of Mechanical Engineers, by Prof. J. Burkitt Webb, of Stevens University. The apparatus is shown in diagrammatic form in Fig. 1. A nozzle *a* was fastened to one end of a pendulum *b* 4 feet long, and connected to the discharge end of a steam pump by a ½-inch rubber hose. The pump supplied a stream under a constant pressure of 100 pounds per square inch. The nozzle was connected by a cord to a spring balance, shown at *c*, which in turn was fastened to the side of the large tank in which the experiment was carried on. The rubber hose was supported by strings, so that its stiffness did not appreciably affect the experiment. In the first experiment made, the jet was discharged into the air, as shown in Fig. 1. As soon as the stream was flowing at its full velocity the pendulum was brought to a vertical position by moving the spring balance, thus eliminating every error due to a deflection of the pendulum. The spring balance now indicated a pull or reaction of 4 pounds.

In the next experiment, shown in Fig. 2, the pendulum was lowered so that the stream of water was discharged about 4 inches below the surface of the water with which the tank was filled. The spring balance was also lowered, and on the repetition of the experiment, with the water issuing from the nozzle under the same pressure as before,

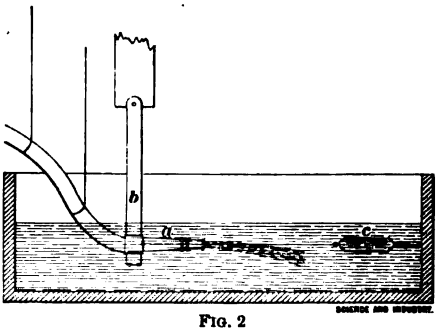

FIG. 2

and the pendulum perpendicular, the reaction or pull was found to be 4 pounds, or exactly the same as when the stream discharged directly into the air.

When these results were reported to the party making the statement, he replied that the reason the reaction in air was the same as when the nozzle was under water was because the jet struck the opposite side of

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the tank and so pushed back on the nozzle. Mr. Everett thereupon suspended the pendulum from the roof of the house, 25 feet above ground, so that the jet issuing from the nozzle would break into spray before striking anything. All other conditions being the same as in the previous experiments, the reaction was found to be 4 pounds, as before. By this simple means the doctor's hypothesis was proved to be entirely wrong, and the truth of the statement that the reaction is entirely independent of the medium into which the stream is discharged was experimentally shown.

Taking up the second claim, its fallacy can readily be shown. It is one of the elementary principles of propulsion that, other things being equal, the most efficient or economical propelling instrument is that which will project the greatest volume of water at the lowest speed. The importance of clearly understanding this proposition, which, to the best of the author's knowledge, was first formulated by Professor Rankine, cannot be overestimated. On first thought, it rather naturally appears to require the same amount of work to project 10 tons of water at 10 feet per second as is required to project 100 tons at 1 foot per second. That this is not the case, however, I shall try to make plain.

Consider that kinetic energy is the amount of work a moving body can do in coming to rest. From this it follows that, to impart a given velocity to a body, an amount of work exactly equal to its kinetic energy must be done on it. Hence, if we calculate its kinetic energy, we also calculate the amount of work required to produce the given velocity. The kinetic energy of a moving body is given by the familiar formula $\frac{WV^2}{2g}$, where $W =$ weight of body, $V =$ velocity in feet per second, and $g = 32.16$. Applying this formula to both cases, it will be found that it requires 10 times as much work to project the smaller quantity of water at the higher velocity.

It may be urged that the propulsive effect is also 10 times as great; this is not the case, however. The thrust, or reaction, is equal to the momentum of the stream projected from the vessel, and as the momentum of a body is equal to the product of its mass and velocity, a simple calculation will show that the propelling force due to projecting 10 tons of water at a velocity of 10 feet per second will be no greater than that obtained by projecting 100 tons at 1 foot per second; while it requires 10 times the amount of work for the smaller stream with the higher velocity.

From this it follows that, in order to have maximum efficiency, the stream of water projected from a vessel should be as large as possible, and its velocity as small as possible. The lowest velocity permissible is, of course, equal to the speed of the vessel, and it should be the aim to keep the velocity of the stream projected from the vessel as near the velocity of the vessel as feasible. From this we see that, if jet propulsion is proposed for a vessel, a very large pump is required in order to project a large body of water at a low velocity. Now, the efficiency of a system of propulsion depends to a very large extent on the power consumed, and, evidently, that system is the best which will give the greatest propulsive effect with the smallest expenditure of power. This, however, is not the commercial efficiency, which is the greatest propulsive effect for the minimum amount of money.

Let us take two parallel cases. In one instance we have a vessel projecting a stream by means of a screw propeller actuated by a triple-expansion engine developing a horsepower on as low as 1.6 pounds of coal per hour. In the other instance take a jet-propelled vessel having an equal speed and built exactly equal to the screw-propelled vessel. Then, as the mechanical efficiency of the pump will be a great deal lower than that of the steam engine, a greater horsepower will be required to get the same thrust as in the screw-propelled vessel. Now, more horsepower means more coal, and, as more coal means more money expended, it will always be found that the screw propeller or paddle wheel will be the more economical system of propulsion. Furthermore, the pump will weigh more and take up more room than the engine used in the other case.

When the low mechanical efficiency of the pump was mentioned, as compared with that of the screw-propeller engine, the comparison was made between the two sets of propelling apparatus in their entirety. That is, the combined efficiency of the engine and propeller wheel, in the case of a screw-propeller engine, is compared with the combined efficiency of the pump, its inlet pipes and outlet pipes, and the fact that water must be continually taken aboard and a velocity imparted to it equal to that of the vessel. The loss in efficiency due to this latter cause may become quite high, and is appreciable under the best conditions.

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From the foregoing it must not be inferred, however, that jet propulsion is not feasible. As a matter of fact, it is perfectly feasible, and even suitable for special conditions if the machinery is designed properly. In England several life boats having jet propellers are in use; and, we believe, are giving good satisfaction in the service for which they were intended. The reason jet propulsion is not employed for larger vessels is not far to find. It is simply due to the fact that it is about the most uneconomical method of propulsion that could be devised, and for that reason if a person becomes infected with the inventing fever, let him apply his ingenuity in more profitable directions. Inventing novel systems of jet propulsion means a waste of time and money, not counting the mental wear and tear occasioned by the rebuffs encountered in bringing the invention to the notice of hard-hearted steamship owners and builders.

THE MECHANICS OF CARPENTRY

(*Continued from the November, 1899, Number*)

Maurice M. Sloan

Determining the Dead-Load Stresses in the Web and Chord Members of a Howe Trussed Highway Bridge

PART XVII

THE preliminary information regarding the loads on bridges and the form of trusses adapted to this class of structures was gathered together in the last article. The application of this data, together with the demonstration of the usual methods employed in the determination of the stresses, the proportioning of members, and the detail design of joints and connections, in at least one form of highway bridge, will be the subject of this and several subsequent articles. Since the Howe trussed bridge, built with timber top and bottom chords and diagonals and iron tension members, offers as interesting and practicable an example as any, the consideration of the subject will be devoted to a bridge of this character.

Assume that the bridge to be designed is to carry a suburban road across a stream, necessitating a distance of 120 feet from center to center of the abutments; the county authorities require that it shall have a width of roadway at least 16 feet in the clear, exclusive of the sidewalks. The height from the surface of the roadway to the under side of the lateral bracing is required to be not less than 14 feet, on account of allowing sufficient headroom to accommodate the usual traffic over such a road. This requirement, therefore, fixes the minimum height of the trusses at 16 feet, approximately, measured from the centers of the chords, and since this height gives a truss of economical proportions, it will be adopted.

The principal dimensions of the bridge trusses are thus determined, and their outline to scale is as designated in Fig. 70, the counterbraces being omitted, as, where the load is uniformly distributed over the full length of the truss, they are subjected to no stress, and are put in for the sake of rigidity and to facilitate better connections at the panel points. The dead load, or the weight of the structure, may be obtained from Table VIII, November, 1899, issue of Science and Industry, and is taken at 800 pounds per lineal foot of bridge, or 400 pounds per lineal foot of truss. Figuring on this basis, the load on each panel of the truss equals 400×12, the length of a panel in feet, or 4,800 pounds.

In considering the dead load on a bridge truss, the panel load is divided equally between the upper and lower panel points; for instance, in this case, the total dead load supported in the vertical line $a\,B$, Fig. 70, is 4,800 pounds, one half of which is considered as located at B while the other half is assumed to act at a. The dead loads on one truss are, therefore, as shown in Fig. 70, and it remains to calculate the stresses that they create in the several members of the truss.

The vertical and diagonal members, which are the web members of the truss, and the stresses of which are called *web stresses*, will be dealt with first. The vertical member $a\,B$, Fig. 70, must sustain, besides the weight B, the accumulation of stresses from all the loads on the truss to the left of the center;

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for example, one-half of e and one-half of F is transmitted to the right and left abutments by the diagonals $e\,E$ and $e\,G$, respectively. Hence, counting e as one, E as two, d as three, etc., the member $a\,B$ must sustain eight loads; $b\,C$, six; $c\,D$, four; etc. The stresses on the vertical members of the truss due to the dead load will then be as follows:

DEAD-LOAD STRESSES IN POUNDS

Vertical Members

$a\,B = 2{,}400 \times 8 = 19{,}200$
$b\,C = 2{,}400 \times 6 = 14{,}400$
$c\,D = 2{,}400 \times 4 = 9{,}600$
$d\,E = 2{,}400 \times 2 = 4{,}800$
$e\,F = 2{,}400 \times 1 = 2{,}400$

While the diagonal compression members $a\,A$, $b\,B$, etc. receive the accumulation of stresses from the center of the truss in the same manner as the vertical rods, the stresses in them represent oblique forces of which the stresses in the tension rods are the vertical components, and the stresses in the chords, between the panel points, are the horizontal components. This being the case, the stresses in the diagonals, as compared with the stresses in the verticals, are as the ratios of their lengths.

This is all more lucidly explained, perhaps, by referring to (*a*), Fig. 71. This figure represents a section of the bridge; $b\,B$ is a diagonal member, and $b\,C$ a vertical tension rod. The load C is transmitted by the vertical rod to the top of the diagonal member, where it is augmented by the weight b, and the accumulated weight at the top of the diagonal is 4,800 pounds. This vertical force, however, creates a vertical reaction of equal amount, as at B, and also the horizontal thrusts x and y, which are resisted by the upper and lower chords.

In this manner there is created, at every panel, a triangle of forces, and the forces are in the same ratio to one another as the sides of the triangle. For instance, the vertical is 16 feet and the horizontal panel distance is 12 feet; if the vertical distance represents unity, or one, the diagonal $= \frac{\sqrt{12^2 + 16^2}}{16} = 1.25$. This value is in reality the secant of the angle that the diagonal makes with the vertical, and referring to (*b*), Fig. 71, its length is expressed trigonometrically as $\sec \theta = \frac{b\,B}{b\,C}$. Having obtained this value, the accumulated loads at each diagonal must be determined, and the stress in each of these members must be found by multiplying this value by the accumulated loads at the diagonal under consideration.

Working with this data and again referring to Fig. 70, the number of loads transmitted to the diagonal $a\,A$, counting from the center of the span with e as one, equals nine. In the same manner, the accumulation of loads on $b\,B$ is seven; and likewise $c\,C$ sustains five; $d\,D$, three; and $e\,E$, one.

The stresses on the diagonal members of the truss may then be tabulated as follows:

DEAD-LOAD STRESSES IN POUNDS

Diagonal Members

$a\,A = 2{,}400 \times 9 \times 1.25 = 27{,}000$
$b\,B = 2{,}400 \times 7 \times 1.25 = 21{,}000$
$c\,C = 2{,}400 \times 5 \times 1.25 = 15{,}000$
$d\,D = 2{,}400 \times 3 \times 1.25 = 9{,}000$
$e\,E = 2{,}400 \times 1 \times 1.25 = 3{,}000$

The results of the preceding calculations show that the stresses in the web members *decrease* from the abutments to the center of the span; this, however, is not the case with the chords, as the stresses in these members *increase* from the abutments to the center of the span, and the accumulation of stresses in the chords at any panel point is due to the sum of the stresses in the diagonals between the panel point in question and the nearest abutment.

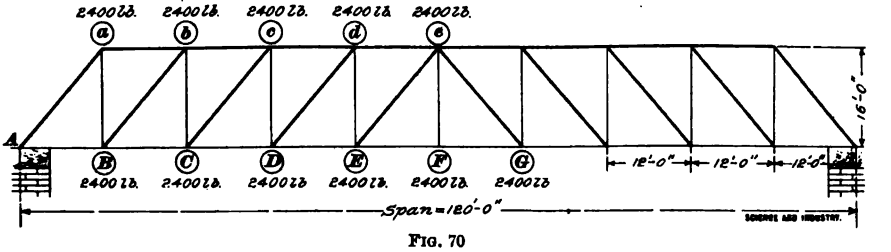

FIG. 70

Since the chord members, like the diagonal members, do not receive the loads direct, but are at more or less of an angle to the line of action of the forces transmitted to them, the value of the chord members in the triangles of forces must be determined. This value is found in the same manner as for the diagonals, and is equal to tan θ, in Fig. 71, or $\frac{12}{16}$, which is .75 of the

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accumulated stresses accruing from the diagonals. Thus, the stress in the portion of the lower chord $A\,B$ is evidently equal to the thrust of the diagonal $a\,A$ multiplied by .75; this stress is tensile and is equal to the

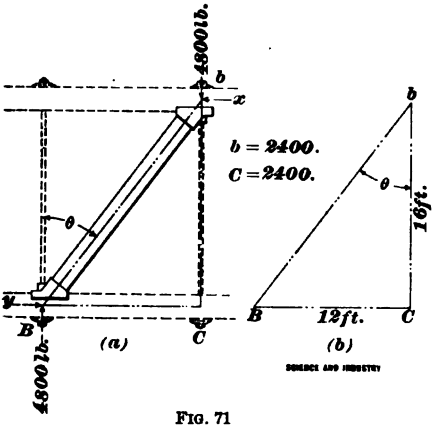

FIG. 71

compressive stress in $a\,b$. The stress in the member $B\,C$, however, is not only equal to the thrust on the diagonal $b\,B$, but it is also required to sustain the stress transmitted to it by the portion of the chord $A\,B$, and equals the compression in $b\,C$. In a like manner the stress in the portion of the chord $C\,D$ equals not only the thrust from the diagonal $c\,C$, but the added stress in the portions of the chord $A\,B$ and $B\,C$.

As was previously determined, the accumulation of loads upon $a\,A$ was nine, and in $b\,B$ seven, while in $c\,C$ it was five. Therefore, the stress in the portion of the chord $A\,B$ equals $2{,}400 \times 9 \times .75$, while $B\,C$ must sustain not only the stress in $A\,B$, but also the stress from the diagonal $b\,B$, and, consequently, must be proportioned to withstand a load of $2{,}400 \times (9+7) \times .75$. In a similar manner, the stresses in the other portions of the chords may be figured, and the calculations tabulated as follows:

$ab = AB = 2{,}400 \times 9$	$= .75 =$	16,200
$bc = BC = 2{,}400 \times (9+7)$	$= .75 =$	28,800
$cd = CD = 2{,}400 \times (9+7+5)$	$= .75 =$	37,800
$de = DE = 2{,}400 \times (9+7+5+3)$	$= .75 =$	43,200
$EF = 2{,}400 \times (9+7+5+3+1)$	$= .75 =$	45,000

All the stresses due to the dead load, or the weight of the bridge structure, are thus obtained, and in a subsequent article the determination of the stresses created by the live load will be considered.

TIME-CARD MAKE-UP

Please describe the method used by street-railway companies in laying out or figuring their time cards. *E. J. B., Detroit, Mich.*

This inquiry we believe to be of sufficient general interest to merit a more extended description than could be accorded in our columns devoted to Answers to Inquiries.

The methods used by various electric railways in laying out their time cards are not all similar, although some of them may agree in small particulars.

When laying out a single-track road, the probable growth of traffic should, of course, be borne in mind, in order that the turnouts may not be too few in number. The character of the service will be governed by the headway with which the cars run. For instance, if it is desired to give a 15-minute service on a particular line requiring 1 hour to make a round trip, it is evident that four cars will be required. The number of turnouts required will be three. In any case the number of cars should not exceed the number of turnouts by more than one. Now, another factor demands consideration, and that is the time occupied in making the run between turnouts. This will, of course, be governed by the character of the country through which the road runs. In open country, the schedule rate may be as high as 20 miles per hour, while in more thickly populated sections, where stops are more frequent and local ordinances have force, this rate may be reduced to 10 miles per hour, or even less.

The applications of these various principles can be best understood by citing a specific example. On a particular line, requiring 1 hour and 20 minutes for a round trip, the headway during business hours is 20 minutes. That section of the line running through the city is used by another branch of the system, on which the headway is also 20 minutes, thus giving practically a 10-minute service. On this first line it is evident that four cars are required. Toward evening, as traffic lightens, it is found that a half-hour service, in place of a 20-minute service, is sufficient. Now, on a line requiring only 1 hour and 20 minutes per round trip, to give a half-hour service, the time would have to be lengthened to 1½ hours per round trip, in order to use three cars.

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A GREAT DISCOVERY

George McC. Robson, M. A.

THE SHAPE OF THE EARTH—PRECESSION OF THE EQUINOXES—THE TIDES—WHAT NEWTON DISCOVERED—LAGRANGE'S EULOGY OF NEWTON

Till old experience do attain
To something like prophetic strain.
—*Milton.*

In the introduction to the third book of the Principia, after briefly reviewing what had been established in the preceding books, Newton lays down four rules of philosophizing: (1) We are not to assume more causes of natural phenomena than are both true and sufficient to explain the observed facts. In this rule a true cause means one that can be detected and whose connection with the phenomenon can be proved. (2) Therefore, to the same effects we must, as far as possible, assign the same causes; e. g., to the fall of stones in Europe and in America. (3) Those qualities of bodies that admit neither of increase nor of decrease of degree, and are found to pertain to all bodies within reach of our experiments, are to be esteemed properties of all bodies. (4) In experimental philosophy, propositions obtained by a wide induction from phenomena are to be regarded as true, or at least very nearly accurate, until other phenomena occur which show that the propositions may be corrected, or are liable to exceptions.

Under the head of *phenomena* Newton then gives a list of astronomical data, taken from the recorded observations of various astronomers. From the examination of these data he concludes that Kepler's laws are approximately true, both for the primary planets and for the satellites. Hence, he shows that a primary planet is held in its orbit by a centripetal force toward the center of the sun, and the orbit of a satellite is governed by a force directed toward the center of its primary; he proves also that this centripetal force acts in accordance with the hypothesis of universal gravitation, and is nothing else than the familiar force of gravity. Whatever may be the force that causes a stone to fall to the ground, it is the same force that regulates the motions of the planets and of their satellites. Thus, Newton found a partial verification of his hypothesis in the broad features of the celestial motions as expressed in Kepler's laws. By this confirmation the doctrine of universal gravitation is promoted from the rank of a mere speculation to that of a working hypothesis. A working hypothesis guides our investigations, and frequently leads to important results that could not be obtained by direct experiment. In proportion as the results thus theoretically obtained are found to agree with observed facts, our confidence in the validity of the hypothesis increases. We shall now consider how Newton applied his working hypothesis to some very interesting problems.

It had long been known that the earth is approximately spherical in shape; but, until Newton's time, no attempt had been made to determine its shape more definitely. By aid of his hypothesis, Newton was able to determine the shape of the earth, or of any planet the length of whose day is known. He recognized that a non-rigid rotating body could not be a true sphere, for the action of centrifugal force would cause it to bulge at its equator. The oblate spheroidal form of a rapidly rotating body is beautifully illustrated by the model shown in Fig. 1; when in rotation, the brass strip *b* assumes the shape of the dotted line, and looks like a transparent spheroid.

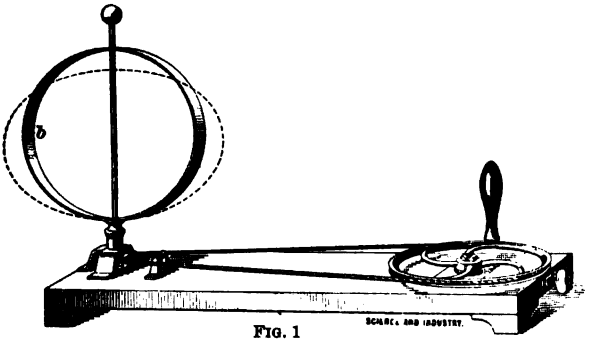

FIG. 1

Newton's investigation of the figure of the earth consists in imagining a great canal,

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full of water, to extend from a point on the equator to the center, and thence to the pole in the shape of a great L. Now, the centrifugal force due to the earth's rotation takes off $\frac{1}{289}$ of the weight of the water in the equatorial leg of this L; hence, in order that the two columns of water may balance each other, the equatorial diameter must exceed the polar diameter. Thus, for the equilibrium of these two columns, the rotation of the earth requires that its shape should not be spherical; this departure of the earth from spherical form introduces a further modification, the amount of which Newton very ingeniously calculates. On the assumption that the earth is homogeneous, he concludes that its equatorial diameter is to its polar diameter as 230 is to 229.

This investigation proves that a plastic body as big as the earth, and rotating in the same period, would assume the form of an oblate spheroid with a difference of 28 miles between its equatorial and polar diameters. The earth is now almost perfectly rigid; but Newton reasoned that if it had always been rigid and had not assumed the oblate spheroidal form, the water of the ocean would pile itself up to a height of 14 miles at the equator, leaving dry land in high latitudes. Since land and water are not distributed in this way, he concluded that the earth had assumed the form of an oblate spheroid.

The glory of making accurate measurements to determine the size and shape of the earth belongs almost entirely to the French. In 1701, Dominic Cassini measured seven degrees of latitude from Amiens to Perpignan, and at a later period the measurement was continued to Dunkirk: it was found that the length of a degree of latitude decreased in going from south to north; which, if the measurements were correct, would prove that the earth is oblong and not oblate. Here was a direct conflict between the result obtained by actual measurement and that derived from the Newtonian hypothesis; but by this time confidence in the theory had become so strong that the English mathematicians maintained that the discrepancy only proved that the figure of the earth could not be found by measuring so short an arc. On the recommendation of the French Academy, expeditions were sent out by the French Government to measure the length of a degree of a meridian in different latitudes. The difficulties encountered in this enterprise were very great, and the measurement of the equatorial degree could not be accomplished in less than eight years. The results obtained established the oblateness of the earth beyond all doubt, but did not yield a satisfactory determination of its amount. The corrected measure of the French arc gave the ratio of the equatorial to the polar diameter as 168 : 167; comparison of the French and Peruvian arcs gave the ratio as 314 : 313; while the ratio derived from the Swedish and Peruvian arcs was 213 : 212. By a very simple arithmetical calculation, guided by a theory, Newton obtained a result that was afterwards verified by an expensive, arduous, and dangerous expedition, which occupied several eminent scientists for years.

Closely associated with this question is the variation of the weight of a body with the latitude. In this connection, we must remember that weight is to be measured by a spring balance. If the earth had no motion of rotation, its spheroidal shape would cause a body weighing 590 poundals at the equator to weigh 591 poundals at the pole. Again, if the earth were a true sphere, its rotation would cause the apparent weight of a body at the equator to be less than its true weight by $\frac{1}{289}$ of the true weight. The total variation of apparent weight arises from the coexistence of these two causes; and the result is that a mass of 194 pounds weighs as much at the pole as a mass of 195 pounds weighs at the equator. Newton applies the theory to calculate the length of the seconds pendulum in various latitudes. From his determination of the earth's shape, Newton was able to explain the precession of the equinoxes, which is one of the most interesting and important of all astronomical phenomena.

The earliest attempt to create a science of astronomy led to the ardent cultivation of a branch of applied mathematics known as *doctrine of the sphere*, in which a great many technical terms were speedily introduced. The celestial sphere was conceived to turn about two diametrically opposite points, or poles, and the great circle midway between these poles was called the *celestial equator*. The sun's apparent path is a great circle, which was called the *ecliptic*. The intersections of these two circles were called the *equinoctial points*, because the days and nights are equal when the sun is at either of these points. The equinoctial point through which the sun passes in spring is called the *first point of Aries*, and is marked ♈, this being the conventional representation of a

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ram's head. All great circles perpendicular to the ecliptic meet in two points called the *poles of the ecliptic*. The position of a point on the celestial sphere can be described by reference to the ecliptic and the great circles perpendicular to it, exactly as we locate a place on the earth by the terrestrial equator and meridians of longitude; indeed, before the invention of pendulum clocks, this was the most convenient way to locate celestial bodies. If a great circle is drawn through any point on the celestial sphere perpendicular to the ecliptic, the arc of the ecliptic measured eastward from the first point of Aries to the foot of the perpendicular, is called the *longitude* of the point; it is important to bear in mind that celestial longitude is measured on the ecliptic and not on the celestial equator.

The path of the sun among the stars cannot be plotted so easily as that of the moon, or of a planet; for, when the sun is in a favorable position for observation, the stars are invisible, and therefore the ecliptic can be traced only by some indirect method. For this purpose, Hipparchus, in the second century of our era, used the eclipses of the moon; for, during a lunar eclipse, the sun is directly opposite to the moon, and therefore the sun's position is known. In this way, Hipparchus detected a slight increase in the longitude of the bright star Spica Virginis. This increase might be due either to a motion of the star in addition to its regular diurnal revolution about the earth, or to a motion of the first point of Aries. Hipparchus examined the places of a large number of stars in different parts of the heavens, and found that the longitudes of all were increasing at the same rate, whence it was evident that the change must be attributed to the motion of the first point of Aries; and he also showed that this motion takes place about the pole of the ecliptic, and not about the pole of the equator. In this investigation, Hipparchus displayed indomitable perseverance and boundless ingenuity in devising and collecting suitable observations; and in the interpretation of these results he showed that he had a perfectly clear and distinct conception of the relative motions involved.

Hipparchus had thus discovered that as the sun moves eastward along the ecliptic, the equinoctial points move westward to meet the sun. This has the effect of shortening the period of time between two successive equinoxes; this phenomenon is called the *precession of the equinoxes*, or, more shortly, *precession*. This curious thing, discovered and partly explained by Hipparchus, is not merely interesting to astronomers, but it has occupied the attention of those that make our civil laws. A tropical year is defined as the period between two successive passages of the sun through the first point of Aries; and, owing to the motion of the equinoctial points, the tropical year is about 20 minutes shorter than it otherwise would be. It is important for many reasons that the civil year, while containing an exact number of days, should correspond as nearly as possible with the tropical year; this correspondence is secured by a complicated system of intercalation, which gives rise to our leap years. Every time a discussion arises as to whether the year 1900 is or is not a leap year, the disputants are dealing with a problem that involves precession.

Copernicus perceived that the explanation of precession could be very much simplified by assuming the diurnal rotation of the earth about its axis. The ordinary statement about the earth's axis—that it remains constantly parallel to itself—is only approximately true. The phenomenon of precession is satisfactorily explained by supposing the axis of the earth to have a slow conical motion, whereby the celestial pole traces a small circle among the stars in about 26,000 years. This is the explanation given by Copernicus, but he complicates it by the erroneous supposition that the precession is unequable. The motion of the north pole among the stars is represented in Fig. 2, which is copied from Sir Robert S. Ball. In precession we have a clue to past history through ages almost endless. By it the dates of the building of the pyramids have been fixed with some degree of probability; and plausible attempts, based on this phenomenon, have been made to determine the periods at which the ancient constellations received their names.

We now come to the third step in the history of this subject—Newton's discovery of the relation of precession to the shape of the earth. By a truly appalling piece of mathematical reasoning, he showed that precession is due to the attraction of the sun and moon on the earth's equatorial protuberance. This explanation could not have been suspected before; for it depends entirely on the shape of the earth, which Newton had just then determined theoretically. Newton had shown that a sphere attracts, and is attracted, as if its whole mass were concentrated at its center; and

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that the same is not true of a spheroid. The attraction of the sun upon the earth is, therefore, an eccentric pull that disturbs the earth's axis of rotation in a manner that Newton was able to calculate. A full explanation of the behavior of a rotating body under the action of an eccentric force

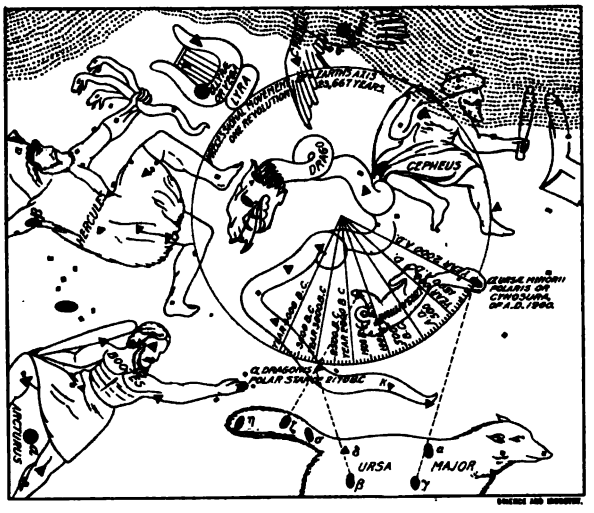

FIG. 2

involves a great deal of mathematics and rigid dynamics. We can only illustrate the phenomenon by some experiments which, though really no simpler than the precession of the equinoxes, have the advantage of not requiring one to live 26,000 years to watch them pass through a complete cycle of changes.

A gyrostat (Fig. 3) consists essentially of a massive wheel capable of rotating freely in bearings attached to a frame. If, while the wheel is not rotating, we attempt to balance the gyrostat on the pivot, as shown in the figure, its weight will drag it down; but if we cause the wheel to rotate very rapidly, and place the frame on the pivot as shown, the gyrostat will not fall down, but will begin to rotate about the pivot. If the wheel is rotated in the direction indicated by the arrow, and if the frame is so placed on the pivot that the axis of the wheel makes an angle of about 23½° with the vertical, we shall have a very fair imitation of the conical motion of the earth's axis. The direction of the conical motion of the gyrostat's axis is indicated by the arrow below the frame. If we imagine the axis produced to trace out the circle *a b c*, we can lay down a simple rule for the direction in which this circle is generated: The circle *a b c* is generated in the same direction as a real cylinder, rotating in the same direction as the wheel, would roll along the inside of the circle. In order that the direction of the conical motion of the gyrostat's axis may correspond with that of the earth's axis, the gyrostat must have its axis inclined downward from the point of support.

Some very instructive experiments can be performed with any ordinary spinning top. An ordinary top is supported on a point below its center of mass, and the force of gravity tends to pull it down; the effect of this pull, combined with the rotation, is to cause the top to reel, so that its axis has a precessional motion in the direction in which the top is rotating. If the top rotates in the same direction as the earth, its precessional motion is, therefore, opposite in direction to that of the earth. If we attempt to push the upper end of the top's axis either toward or away from the vertical, the axis does not move in the direction of the push, but its rate of precession changes. A spinning top, suspended from the upper extremity of its axis, has a precessional motion similar to that of the earth.

In addition to the precession discovered by Hipparchus, Newton recognized that the oblateness of the earth must produce another slight irregularity of the motion of the earth's axis; this he called *nutation* (nodding). The nutation of the earth's axis is a small vibratory motion toward and from the plane of the ecliptic. Newton asserted that its amount is so small as to be scarcely perceptible. Even after its existence had been pointed out by Newton, it required consummate skill on the part of Bradley—the third British Astronomer Royal and a very accomplished observer—to detect it by astronomical observations.

The ebb and flow of the tide is a phenomenon of high importance to mankind, and from its direct influence on navigation it has necessarily attracted great attention. There is a legend that a great philosopher, driven to desperation by his inability to explain the tides, drowned himself in the sea. Kepler associated the tides with the moon, and said that the waters of the ocean

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followed the moon in her journey round the earth. For this he was most unmercifully chaffed by Galileo, who said it was pure superstition to connect the tide with the moon. Newton laid the foundation of the tidal theory, and showed that the main features of the tides are due to the attraction of moon and sun on the waters of the ocean. Those of our readers that are interested and wish to see this very abstruse subject at once popularly and scientifically explained, should read Prof. G. H. Darwin's book on the tides.

The comets are indebted to Newton for their admission to the privileges of citizenship in the solar system. Regarding them as subject to the control of gravitation, he recognized their orbits as very elongated ellipses; and, therefore, the same comet must return again and again at equal intervals of time, except in so far as its path is disturbed when it passes near one of the great planets. In 1682, Halley observed a comet, and calculated its orbit on Newtonian principles; he determined both the dates of its past and of its future appearances. He found that it had been seen in 1607 by Kepler, and in 1531 by Appian, and predicted that it would reappear about the year 1758. Halley lived to a good old age, but died before the expected return of his comet. When the time drew near, Clairaut made a very careful computation of the perturbing influence of Jupiter, near which the comet had passed, and predicted its return for April 13, 1759, at the same time stating that he might have made an error of a month. The comet took advantage of the full limit he allowed, for it returned on the 13th of March, 1759.

Thus Newton found that in every department in which practical astronomy could furnish trustworthy data, his working hypothesis was abundantly able to account for all the phenomena—the most minute as well as the greatest. His theory explained all the order that had been observed amid the perpetual change and apparent disorder of the heavens, and it equally accounted for all the fluctuations and apparent irregularities detected in the celestial motions. Starting from three simple principles derived from experience—principles so simple that he calls them axioms—he had been able not only to explain known facts, but also to predict things that would afterwards be observed. Greater wonders even than these have been achieved through his theory. By it, M. Le Verrier and Mr. Adams—two very brilliant young mathematicians—working quite independently, were able to discover the existence of an unknown planet, and to direct the astronomers in their observatories where to look for this great planet at a given time. The calculations of Le Verrier and Adams were based on some discrepancies between the observed and the calculated longitudes of the planet Uranus, which had been discovered in 1781 by Sir William Herschel.

It remains for us yet to give a definite answer to the question: What did Newton discover? Newton's writings contain no explicit statement of the hypothesis of universal gravitation, though separate parts of it are found in different passages of the Principia. By combining these detached parts, the modern enunciation of the hypothesis has been obtained, and this general statement is now called the *law of universal gravitation*. It is usually said that Newton's discovery is the law of universal gravitation, and this statement is perfectly correct if the phrase "law of universal gravitation" is rightly interpreted.

What do we mean by law in science? When we say that Jupiter obeys the law of

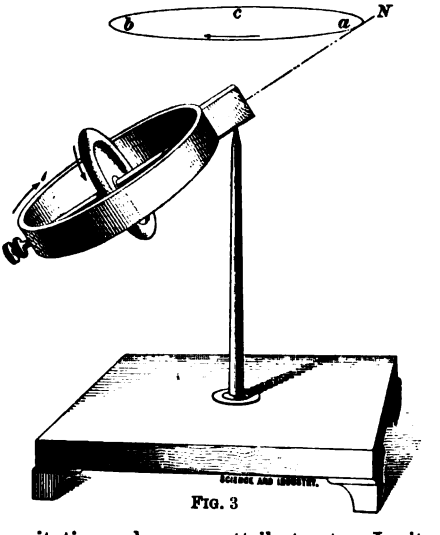

FIG. 3

gravitation, do we attribute to Jupiter moral faculties and a will by which the planet can determine its own conduct? Could Uranus, in 1840, have been indicted before some high court of the universe for wilful and malicious violation of law, by which the harmony of the solar system was grievously perturbed? Can we imagine the planet making the defense that his intentions

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were honorable and that he was doing his very best to obey the law; that he was a good citizen and had a family of six; that it was not with any evil design that he traveled under different names—sometimes calling himself Uranus, sometimes Herschel, sometimes Georgium Sidus; that his apparently wilful transgressions were caused by a disreputable-looking stranger that frequently assaulted him and pulled his coat to make him swerve from his appointed path? When we think of the matter in this light we recognize that a physical law is something entirely different from a moral or a civil law.

Having thus cleared the ground by determining what a physical law is not, we are in a better position to investigate what it is. The most eminent physicists of the present time declare that the principal business of science is the tracing of analogies or similarities, so that we can group a large number of phenomena together in a single class. The scientific explanation of an event consists in establishing an analogy between that event and some other event with which we are familiar. Newton explained the motion of the moon when he established the analogy between the moon's motion and the fall of a stone. The trend of scientific thought seems to be toward some such definition as the following: A physical law is a general statement of similarities in natural phenomena. The law derives its value from the assumption that the events of the future and phenomena beyond our reach will display the same analogies and similarities as those we have observed. When it is asserted that a physical law has been tested and approved by experiments, the range of the experiments should be stated; and only within that range is the law known to be true.

What, then, do we mean by the word *universal* in the phrase *law of universal gravitation?* Newton's fourth rule of philosophy supplies the key to the interpretation. Since it has been found that the law of gravitation is applicable to all the matter in the solar system, we are to assume that it applies to all matter everywhere until some reason to the contrary has been discovered. The observed motions of multiple stars tend to confirm the hypothesis that the law of gravitation applies to the matter in those systems, though it cannot be said that this has been proved.

The last word whose meaning we have to discuss is *gravitation*. What is gravity? Our idea of gravity is derived from our sense of effort when we raise a body from the ground, or prevent one from falling. Hence, we say that the earth attracts the body, or the body gravitates toward the earth; but we know nothing of the cause or mechanism of this attraction. At the end of the Principia Newton says: "Hitherto I have not been able to discover the cause of those properties of gravity from phenomena, and I frame no hypothesis." In a letter to Bentley, dated January 17, 1692 (i. e., 1693 of our calendar) he remarks: "You sometimes speak of gravity as essential and inherent to matter. Pray do not ascribe that notion to me, for the cause of gravity is what I do not pretend to know, and therefore would take more time to consider of it." In a subsequent letter to Bentley, dated February 25, 1692 (1693), he writes: "That gravity should be innate, inherent, and essential to matter, so that one body can act upon another at a distance, through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it." In his "Optics" he speaks of the ether as a subtile medium filling all space, and freely penetrating through all matter, and he speculates that heat and light may be propagated by the vibrations of this medium, and tries to imagine a medium with such properties that it would account for the phenomena of heat, light, and gravitation.

The ether has been very hard worked of late, but physicists have strong hopes that sometime they will be able to attribute to it such qualities as will enable it to embrace the phenomena of gravitation as well as those of electricity and magnetism; and that thus they may be able to correlate the seven or eight forms of energy that they are still compelled to consider as distinct. Some of the speculations of mathematical physicists along this line are profoundly interesting, but their development is impeded by almost insuperable mathematical difficulties.

If the reader will dissociate the term *mass* from its direct connection with the idea of quantity of matter, we can state Newton's discovery in a form more consonant with modern ideas. The discovery that characterizes the Principia is, *to any body A we can assign a constant, called its mass, such that any other body has an acceleration toward A proportional to the mass of A divided by the square of the distance between the bodies.*

The manuscript of the Principia was

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completed in 1686, and it was published in the summer of 1687. Its effect can best be described by quoting a favorite saying of Lagrange, that Newton was not only the greatest genius that ever existed, but he was also the most fortunate; for, as there is but one universe, it can happen to but one man to be the interpreter of its laws. It is interesting to place beside this generous eulogy Newton's own modest statement, "If I have seen further than other men it is because I stood upon the shoulders of giants." The English Government showed its appreciation of Newton by his appointment in 1696 as warden, and his promotion in 1699 to the mastership of the mint. In 1705 he was knighted by the king.

He passed away from the scene of his labors on March 20, 1727, in the eighty-fifth year of his age. He was interred in Westminster Abbey, the pall being borne by the Lord Chancellor and several of the leading noblemen. A stately monument has been erected to his memory, with emblematic representations of some of his discoveries. A short time before his death he gave utterance to this characteristic sentiment: "I do not know what I may appear to the world; but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

WATER FILTRATION AT HOME

Thos. N. Thomson

How to Obtain Pure Water While Others Are Drinking Mud—Quack Filters, and How to Know Them—Germ-Proof Filters

THE greater part of the water consumed in cities for drinking and cooking purposes, although falling from the heavens quite pure in the form of rain, becomes contaminated on its way to the reservoirs, and often in the reservoirs themselves. Not only does the pure rain water absorb mineral impurities as it travels down the hill or mountain sides, but it often becomes highly impregnated with mud, decayed vegetation, and even with the excrement from sheep and cattle. When these little highland streams reach the reservoir they are often so very turbid as to be nearly as dark as stale ale, and much thicker. Most of the matter held in suspension settles on the bottom of the reservoir, and the water, when allowed to stand, ultimately becomes fairly clear before it enters the main pipe lines. A reservoir may, however, become so turbid throughout after a heavy shower that it is no uncommon occurrence for the muddy water to enter the street mains and be drawn from the faucets in that condition. It would only be reasonable to expect the water companies to build large filtering beds at their reservoirs, so that all foreign matter held in suspension by the water would be intercepted at the filters before the water could enter the street mains; but many reservoirs do not have any filters, and, consequently, the people supplied get the water just as it lies in the reservoir, or perhaps worse yet if the mains are in bad condition.

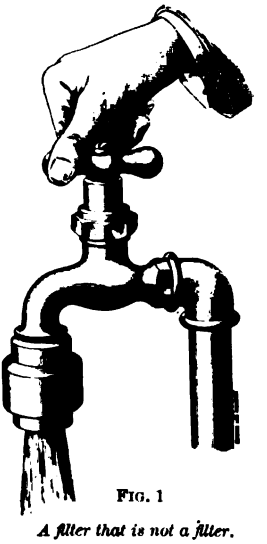

FIG. 1

A filter that is not a filter.

Many reservoirs, it is true, are equipped with filters, but very often these are so constructed that they can intercept only such objects as branches of trees, twigs, dead cats, etc., being of no use whatever either in intercepting germs of disease or in clarifying the water.

Sand and gravel filters do not and cannot intercept bacteria, for the spaces between the filtering material are large enough to let these minute organisms go through a hundred abreast, if such a thing could be imagined. If water companies would place germ-proof filters at their reservoirs that would not only intercept germs but also clarify the water as clear as crystal, and if the street

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mains could be kept thoroughly clean inside, there would be no use at all for the public troubling about the quality of the water used in their homes, because it would come to them perfectly clear, pure, safe, and wholesome. But water companies will not do this, and the public does not seem to care much whether they do it or not. The result of public lethargy in this matter and the lack of public spirit in the way of opposing the tyranny of water corporations, is that the water supplies of many cities today are so thoroughly contaminated with animal and vegetable matter that peculiar diseases are found to exist, and have even become epidemic in certain sections supplied by these contaminated waters.

Filter after filter has been purchased of different dealers, and mayhap pedlers, too, by the more intelligent residents of cities, at prices ranging from ten cents to perhaps five dollars, for the purpose of getting pure water for home consumption, and then utterly failed. The market for

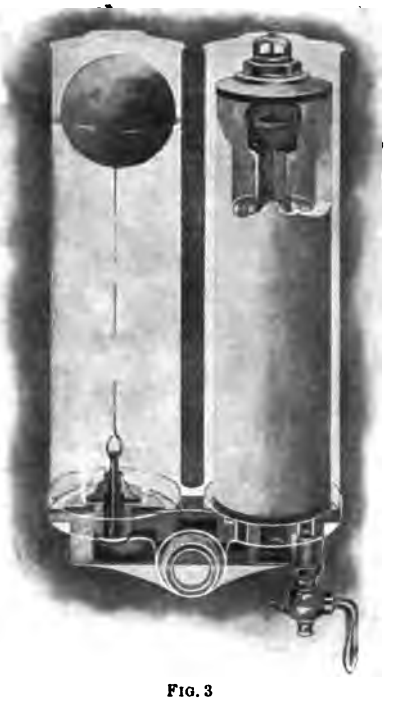

FIG. 3
Interior construction of a germ-proof filter.

the past ten years has been flooded with innumerable quack filters that do not filter, and some that do filter, but are nearly as bad as those that do not. By the foregoing we refer to some of those abominable things that people screw on faucets at kitchen sinks. They never can filter properly, for they are built wrong; they are simply screens that hold back large matter carried by the water, such as small fish, worms, parts of leaves, etc. The reason why such filters do not operate is that the filtering beds are too small and the filtering passages too large, and the velocity of the water passing through the filtering material is altogether too high for efficient filtration. These humbugs are worse than useless, because they give to the public a feeling of security that is false in the extreme. They are made and sold chiefly to meet the great demand of the present time for cheap goods.

If disease germs are to be filtered from water, it is necessary that the filters operate very slowly, because the filtering material must be so close that the water will simply ooze through it, even when subject to high pressure, and its surface must be large, so

FIG. 2
A filter that is a filter.

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that the quantity exuded, when collected, will form at least a small stream. There are several filters on the market today that are built on the germ-proof principle, and no doubt they are germ-proof, but the filtering material of many of them becomes so clogged up in a short space of time that the public appears to think that the mere getting of pure water is not worth the trouble involved in cleaning them; hence, there appears to be little demand even for a germ-proof non-self-cleaning filter. We do not mean any reflection on the merits of non-self-cleaning germ-proof filters, because the first object of a filter is not that it should be self-cleaning, but that it should furnish perfectly clear pure water, free from disease germs. Many of the filters on the market today are excellent filters if the public will only clean them out properly.

A new filter that is now being placed on the market seems to be built on proper principles. Fig. 2 shows one of them attached to the cold-water pipe of a kitchen sink at the back of the cold-water faucet, and the lady seen in the illustration is drawing a glass of filtered water. Fig. 3 shows the construction of this filter. It is composed of two nickelplated polished casings; the one on the right hand surrounds the filtering tube, while the one on the left serves as a reservoir for filtered water. This attachment filters from 15 to 50 gallons a day, according to the pressure. The main object of the reservoir shown in the figure is to hold in reserve a supply of drinking water that, though limited, is always ready to furnish a cool drink when wanted. The interior of the filter is lined with block tin to prevent the water stored there from being contaminated with metallic poisons. It is 12½ inches high, and weighs about 8 pounds, complete. The filtering tube is a hollow cylinder made of specially prepared, fine, porcelain composition. The water from the sink faucet, which is used to draw off unfiltered water for ordinary purposes, is employed to keep the filtered water cool; every time water is drawn from the sink faucet a current is made to circulate around the filtering cylinder, thus keeping the cylinder clean and its contents cool. The manufacturers claim that this flushing action thoroughly cleans the filter, thus making it automatically self-cleaning.

Now that a germ-proof self-cleaning filter can be purchased, and since all objections to quack filters seem to be overcome, there appears to be only one thing that can stand between the water-consuming public and perfectly pure water, and that is twelve and one-half dollars—the price of this modern filter. There are cheaper germ-proof filters in the market, but we do not know of any that are more worthy of a place in the home than the filter shown here.

NOTE.—We are indebted to The Metropolitan Filter Company, 97 Washington Street, Chicago, Ill., for Figs. 2 and 3.

MECHANICS

By the "Professor"

MECHANICS is that science which treats of the action of forces on bodies, and the effects they produce; it treats of the laws governing the equilibrium and movement of bodies, and shows how they may be utilized. According to the effects that forces produce on a body, the science of mechanics is subdivided into mechanics of *solid bodies*, mechanics of *fluids*, and mechanics of *heat*, or *thermodynamics*.

Mechanics of solid bodies is subdivided again into *statics* and *kinetics*, or *dynamics*, as it is commonly called.

Mechanics of fluids is subdivided into mechanics of *air* and *gases*, or *pneumatics*, and mechanics of *liquids*. The latter is divided into *hydrostatics* and *hydrokinetics*—the common expression for the last term being *hydraulics*, and, also, *hydrodynamics*.

Statics treats of the conditions of the equilibrium of bodies. *Kinetics* or *dynamics* treats of bodies in motion and the effects they may produce.

Pneumatics treats of the laws of the pressure and of the movement of air and other gaseous bodies. *Hydrostatics* treats of the equilibrium of liquids. *Hydrokinetics* treats of liquids in motion, and the effect they may produce. *Thermodynamics* treats of the mechanical effects of heat on bodies.

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CHAINS AND THEIR USE

H. Rolfe

CHAINS OBLIQUE TO LINE OF PULL—TWO MAIN KINDS OF DETERIORATION—BAD AND SUSPICIOUS WELDS—END WEAR—FORM OF LINKS—ANNEALING

IN THE last article reference was made to the increased pull in the sides of a stud link, due to the link being so distorted as to throw the sides at an angle with the line of pull. Attention will now be drawn to a somewhat similar contingency — one where the chain as a whole is inclined to the line of pull. This is a matter very frequently overlooked in using sling chains, the fact being ignored that the greater the angle formed by the two chains $a\,c$, $d\,c$, Fig. 1, the greater will be the pull in them with a given load W. If we lift, say, 4 tons by a double chain, Fig. 2 (a), there will be a pull of 2 tons in each chain, for both are parallel to the line of pull. If, however, we use it as in Fig. 2 (b), the pull in each chain will bear the same ratio to half the load as $a\,c$ does to $b\,c$, Fig. 1. (Compare the case in the last article, page 46.) Or, we can measure $a\,c$ and $b\,c$, and then multiply the half load by the former and divide by the latter, to find the pull in the chain; or, again, if we know the angle $a\,c\,d$ made by the two chains, the pull $P = \frac{W}{2} \times \sec \frac{1}{2}\,a\,c\,d$. If $W = 4$ tons, and $a\,c\,d$ is 60°, $P = 2 \sec 30° = 2 \times 1.155 = 2\frac{1}{3}$ tons, nearly, an increase of $15\frac{1}{2}$ per cent. What is here said of the ordinary two-chain sling applies, of course, to slings of more than that number of chains. We may adduce, as an instance of chains being thus spread out as in Fig. 1, the case of lifting rolls of lead. These are generally of a considerable length, and thus, with ordinary lengths of sling, make quite a large angle (see a, Fig. 3), increasing the stress in the chain considerably.

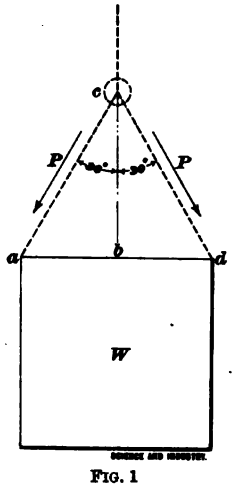

FIG. 1

The writer knew of a case where a man's life was lost in this way. The workman in charge subsequently admitted, innocently enough, that he had kept the slings as short as possible, owing to not having much headroom. With a straight lift (i. e., with the chain in line with pull) this would, of course, not matter, but in the above case the effect was to increase the stress in the chain considerably, a fact of which the man in charge was altogether unaware. The actual angle was proved to have been about 115°; thus, with a load of 3,000 pounds, instead of having a 1,500-pound pull in the chain, as expected and provided for (assuming steady lift), there was a pull of $1{,}500 \times \sec 57\frac{1}{2}°$, or $1{,}500 \times 1.86 = 2{,}790$ pounds, an increase of 1,290 pounds, or 86 per cent. The fact that the chain was rusted and the links much worn at the ends had helped on the failure, as was evident even to the unpracticed eyes of the "twelve intelligent men" on the jury, on its being pointed out to them by one of their number who possessed rather more acumen than the rest. The defective state of the chain induced the jury to append to the verdict a rider censuring the railroad

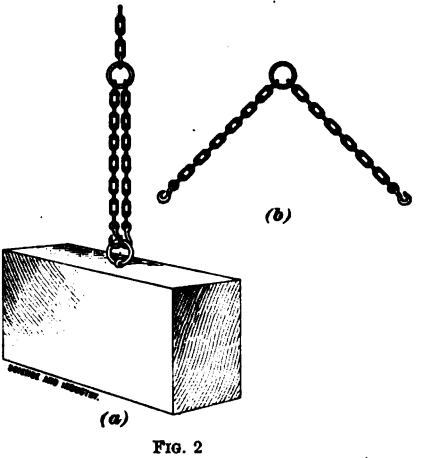

FIG. 2

company on whose premises the accident occurred.

Among the very large number of cranes, large and small, in use on a large railroad system, there is sure, as in the above case, to be great neglect if they are left to the care

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of the men operating the cranes. These men are ordinary station employes, or, in fact, any one else that happens to be around. Such persons know nothing, and care less, about mechanical matters. What is wanted is supervision by a proper corps of inspectors, making periodical examinations, and with instructions to cut out any link found unduly lengthened or worn, or to take any chain out of service at their discretion.

It has been found by ample experiment that the ultimate strength of chains is, on an average, $1\frac{1}{8}$ times that of the bar from which the links are made. Thus, the breaking strength of $\frac{3}{4}$-inch round iron is about 23,000 pounds, and that of the link itself about 37,000 pounds. Such a chain may be tested up to 14,500 pounds, and half of this adopted as the working load. It is not advisable to use a severer proof load than the above, as it would permanently distort the links. The

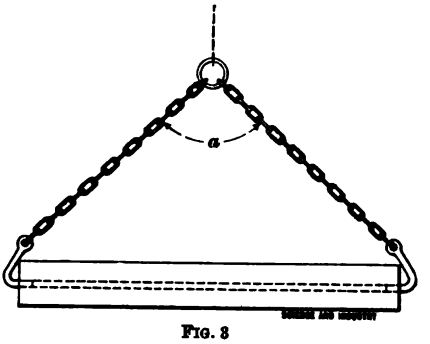

FIG. 3

best course is to cut off a portion of the chain and test it to destruction—that is, till it breaks.

All chains undergo a deterioration that may be divided into two kinds—visible and invisible, or mechanical and molecular. The first kind of wear is confined to certain parts of the links, and is readily perceived and dealt with. The second is an alteration in the nature or structure of the material. This is not so readily determined, either as to its mere existence or its extent.

The visible wear depends on the design of the chain and of the parts it works in contact with; the second kind of wear depends on the nature of the work. We have already pointed out that the links should not be too long for the diameter of barrel; on the other hand, the shorter they are, the more welds we shall have in a given length of chain, and, therefore, the greater chance of a defect. Also, we remarked on the efficacy of a properly designed grooved pulley; such a one is much better than a pulley with too large a channel or race, because the latter allows the chain to roll about with a very violent motion under the heavy pull. This may induce twists, besides wearing the chain away.

FIG. 4

Chains, new or old, should be examined for twists, as such a thing causes considerable wear. The loss of material due to rust is also to be considered. Where chains are always exposed, as on outdoor cranes, they should be given an occasional coal-tar bath.

We often speak of the "personal equation" in connection with engineering matters; this item enters largely into the matter of chain making. One link of a chain or one end of a link will often show considerably more wear than the other, although made out of the same brand of iron. We are well aware that differences in strength and quality may be expected, not only in the same brand but even in the same bar; differences, however, insufficient to account for the variation in wear that we have often observed. The cause, in fact, is either an improper welding temperature or else too much working up on the anvil. Particular care should be taken not to impair the quality of the iron in the bend of the link, for it is here that the wear is greatest. The end, in fact, is the critical part of the link, not only on account of the bending stresses in the outer part of the bend, but also because of the crushing and upsetting of the fibers on the inside of the bend, which latter effect renders the metal less able to stand the severe pressure that comes on it at that point.

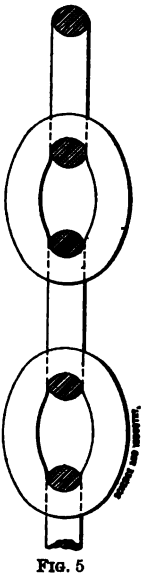

FIG. 5

Here we may say something about defective welds. These may be divided into two groups: *first*, those due to the faulty temperature at which the weld was made; *second*, those caused by dirt or scale. In the first case, if the temperature is not right, a true junction of the surfaces will not take place; in the second, the layer of dirt or scale prevents the two pieces of metal uniting.

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In chains, these bad welds often escape examination, for, in scarfing the ends of the link, the surfaces are generally hammered more or less hollow, and in these hollows the dirt collects, the edges, however, uniting pretty thoroughly. The only hope of discovering this state of affairs lies in the tensile test; and even then, considering that only 50 per cent. of the breaking strength is used as a proof test, there is no chance of detecting such links if the bad area is less than 50 per cent. of the total section; still, we can note the extra elongation. A weld like those of the second group is shown in Fig. 4, the dark part of the section showing where the scale prevented metallic junction. The other welds (belonging to the first group) are more easily detected, for the low temperature prevents the edges of the weld from being neatly joined. However, as is very well known, a bad joint, does not always indicate a bad weld, for when the edges are extra thin, a suspicious appearance is induced, since they cool so much quicker than the main body of the joint, thus preventing them from uniting nicely.

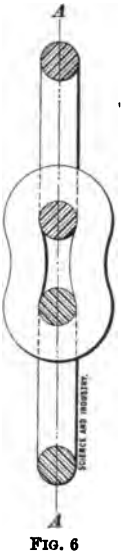

FIG. 6

We have already spoken of end wear. This is due to motion under heavy pull, unattended by proper lubrication, and aggravated by exposure—inducing rust. When the wear is extreme on both links, as in Fig. 5, the effect is twofold: the sectional area is decreased, and the free action of the chain is interfered with—the links cannot play freely on one another. A little thought will make our meaning apparent to any one who may never have handled such a chain. This intimate fit also prevents the grease or oil from entering between the surfaces at the ends of the links. On the other hand, when chains are new, the contact between two links is very small, and this causes a very great pressure per unit area, which prevents oil getting in, or squeezes out what is already there, especially if the oil has little body.

Considering the nature of the work endured by chains, it is desirable that they should be able to "give," to a certain extent. This elasticity is provided in two ways: *first*, by using a ductile material; *second*, by making the links of a peculiar form. A chain should stretch readily under its working load, but resume its original length when the load is removed. We can see what form the links tend to take under severe loads by testing a piece of chain to destruction; the sides of the links will approach each other as shown in Fig. 6, the effect being more noticeable when the links are long and of comparatively light section—rather more so than in the figure. This effect has been noticed in chains that have been subject to violent treatment, as in the case of some crane chains. Referring to the illustration, it looks as if the sides were trying to get into a position to let the line of pull *A A* pass through them; acting on this hint, we curve the links the other way and make them as in Fig. 7. The superiority of this over the parallel form will be felt intuitively. Of course, the link must not be too much bellied or it will not recover its shape when the load is released; so we may just as well start with only a moderate amount of curvature.

We have already alluded to the process of annealing. This should be done properly, if done at all. If there is a furnace, the chains may be put in it and heated slowly, and kept at the proper heat—about 1,350° F.—for an hour, then cooled off slowly in smiths' ashes; foundry sand will do as well. The heat should, as remarked, be hot enough, but not so hot as to waste the links by scaling.

It will be readily understood that excess of temperature, high or low, will affect chains. Excessive cold makes the chain brittle; therefore, outdoor chains call for more careful handling in severe weather. Also, sudden and repeated changes of temperature are bad, and affect the iron injuriously.

To sum up, the life of a chain depends very largely on the care with which it is used. In fixing on the working loads, it should be remembered that the larger the chain, that is, the thicker the bar from which it is made, the weaker is it proportionately; this is partly due to the fact that the iron in the larger sizes of links is not of such good quality. As to end wear: if a link, on being calipered, shows a decrease of $\frac{1}{8}$ of the diameter, it will be found, on calculation, that there is a decrease of over 21 per cent. of the sectional area, which means an increase in the stress of about 27 per cent. So a rule should be made to condemn a chain when any of the links show a certain predetermined amount of wear.

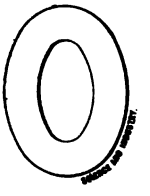
FIG. 7

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FIRES FROM DEFECTIVE ELECTRIC WIRING

FREQUENCY OF ELECTRIC FIRES—PRECAUTIONS AGAINST FIRES—DEFECTIVE WIRING

EVERY now and then we read in the public press of some large fire that has been caused by defective electric-light or power wiring. This was reported as the cause of the recent disastrous fire in Philadelphia that resulted in a large loss.

It may be well to state at the outset that the writer believes that many of the fires attributed to electricity would, if their true origin were known, be found due to other causes. Electricity is a very handy scapegoat on which to lay the blame of many fires, the origin of which is uncertain. The public mind looks upon electricity as a mysterious agent that is liable to cause all sorts of damage, and is willing to take it for granted that it is the cause of any fire that cannot otherwise be explained. The impression has, therefore, gone abroad through the land that electricity is very dangerous in this respect, and the idea is prevalent that a great many more fires are started from electric wires than is really the case. The fact that these wires are generally out of sight makes this view all the more acceptable to the public mind, because nobody ever knows just how the fire was started and the blame is laid on the electric wires because they are concealed, and nobody can dispute the claim unless the true cause of the fire is discovered later.

As a matter of fact, electricity is the safest means of illumination in use today. Theaters, for example, are ever so much safer from fire than when open gas jets were used, and the same is true of factories and even private residences. The oil lamp is certainly not as safe a means of illumination as the incandescent lamp. If the accidents due to lamp explosions alone were compared with the fires really due to electric wires, we feel quite sure that electricity would not suffer by the comparison. There is no doubt that fires are caused by defective wiring, but the number of fires directly traceable to this cause is not by any means as large as the newspaper accounts would lead us to believe. In fact, if poor wiring caused fires as easily as many suppose, some towns would have suffered severely by this time, because the wiring in many of them has certainly been very poor and unsafe, according to present standards. The writer has in mind a city of thirty or forty thousand inhabitants, in New York State, that was provided with an electric-light plant in the early days of electric lighting; in fact, it was one of the earliest plants installed by the Edison company, and at that time the art of interior wiring was not by any means highly developed. The plant was operated on the Edison three-wire system, with 220 volts between the outside wires, and the current was supplied through Edison underground tubes, which, by the way, were always more or less grounded. The wiring in a great many places was done with the old underwriters' wire, insulated with cotton treated with white lead; a type of wire that is now prohibited by the underwriters for interior work. All the cut-outs, cleats, switch boxes, etc. were of wood, and in many places the wiring was even run around the interior woodwork with staples. In fact, a good deal of the wiring in those days was done by men whose principal business had been putting up electric bells and burglar alarms, and they put in electric-light wires in much the same way as they had been accustomed to running bell wires. Such wiring today would not be dreamed of, but nevertheless the above plant supplied light and power through this wiring for over ten years, and during all that time there was only one fire that was traceable to the defective wiring, although the conditions for such fires were about as favorable as could be imagined. This example is not to be taken as a defense for poor wiring, because there is no excuse for it, but it does indicate that fires from this cause do not occur as easily as some people imagine.

The fact, however, remains that fires have been caused by defective wiring, and this is amply sufficient to make sure that all wiring is carried out in a proper manner. It would be an endless task to attempt to take up all the various causes that may lead to fires of this kind, but if the wiring is thoroughly well installed there is very little likelihood of such fires occurring, so far as the wiring itself is concerned. The best general rule that can be given as a guide to safe wiring is to follow the rules of the National Board of Fire Underwriters. These rules have been carefully prepared, and to many men they seem in some respects to be too harsh and exacting, but they have been carefully drawn up with a view to securing safety,

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and, if followed, will lead to good results. There are a number of different systems that can be used for wiring a building, the safest of which is probably that where the wires are run in an iron conduit. This, however, is expensive to install, and can only be used in high-class buildings where the additional expense is warranted. For ordinary concealed work the wire is usually run on porcelain knobs between the beams, or passes through them in the porcelain tubes. If a good quality of rubber-covered wire is used and installed throughout in accordance with the underwriters' rules, this style of wiring is perfectly safe, and is comparatively cheap to install. One point that is looked after too little is the making of joints. Very often these are imperfectly made, not even soldered, and then covered with a rough wrapping of tape. It is a common thing to see great care exercised in the choice of a good covered wire, and then very little attention paid to the way in which the joints are insulated. It goes without saying that the insulation at the joints should be equal to that of the rest of the wire. Joints are often wrapped over with tape while they are wet with acid, whereas they should be perfectly dry before being wrapped, and acid should, preferably, not be used for soldering. A resin flux is much better.

Another thing to look out for, in order to secure a safe job, is the judicious use and location of cut-outs. In many installations there is but one fuse box—that where the wires enter the building—whereas the underwriters' rules call for a cut-out wherever there is a change in the size of the wire, unless the fuse in the main cut-out does not exceed the carrying capacity of the smaller wire. All cut-outs should be placed where they may be readily examined, and not over the top shelf of some dark closet or in some inaccessible portion of the cellar, as is too frequently the case. Moreover, cut-outs should not be fused up with copper wire when the fuse persists in blowing.

Another point to look out for in putting up wire, especially Nos. 12 or 14, is to take care that the wire does not become kinked. Even if these kinks are straightened out the wire may be cracked if it is not of good soft quality. Fires have resulted from broken wires of this kind. One instance occurred on a Hudson River ferry boat. The No. 14 wire was run in molding and had evidently become kinked in putting up. Straightening out the kink had cracked the wire, but this was not noticed on account of the insulation holding the ends tightly together. The vibration of the boat, however, worked the ends apart in time, with the result that an arc was formed, setting the insulation on fire and burning a hole through the molding. This fire was at once discovered and put out, but it shows that a small thing like this might be the means of starting a bad fire; moreover, this is a defect against which the cut-outs give no protection, because the normal current would set up an arc large enough to start a fire.

As regards power circuits, the rules of the underwriters should be carried out as carefully as in the case of lighting circuits; in fact, even greater care should be exercised, because usually both the current and voltage to be handled are larger. Every motor should be equipped with an automatic overload and no-voltage starting box. It is also desirable that they should be equipped with an automatic circuit breaker, which is now compulsory in some places.

After all, the greatest safeguard against fires is thoroughly good work, with intelligent supervision and inspection. If some uniform system of inspection were adopted, so that all contractors would have to do the same quality of work, much better results would follow. In some places the work is not tested or inspected until it is all covered up and therefore the good work looks no better than the bad. People are continually wanting all sorts of switching arrangements and other conveniences in connection with their electrical outfit, without being willing to stand the additional expense. Competition in the wiring business is very keen, and the temptation to slight the concealed work is strong. Nevertheless, electrical installations are improving every day; the fittings now used are vastly superior to those of a few years ago, and there is no reason why, at present, a good safe job of wiring cannot be done at a reasonable cost. In conclusion, it might be well to call attention to the fact that, no matter how well a system may be installed originally, it is bound to give trouble and perhaps lead to serious results if the owners will persist in overloading it. It is an easy matter to keep adding a few lamps here and there until something breaks down, and then the wiring is blamed for some fire because it is trying to take care of a load for which it was never designed. Let every wireman follow the underwriters' rules, if not to the letter, at least in spirit, and fires due to electrical causes will be even less frequent than they are now.

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MAKING BLUE TRANSPARENCIES

Francis Douglas

METHOD OF PREPARING THE PLATES—A NEW USE FOR SPOILED DRY PLATES

ONE of the many interesting experiments in modern photography is that of making blue transparencies. So simple and inexpensive is the process that, when once known, it is certain to become useful as well as popular with those interested in the photographic art. The process solves the problem of utilizing discarded negatives, light-struck plates, and exposed plates that have not been developed. By the method to be explained, these plates can be used again with the most satisfactory results.

First, thoroughly cleanse the negative plates by soaking them for 24 hours in a solution of washing soda, using 2 ounces of the soda to 1 quart of water; then remove any remaining film, by the use of an old tooth brush. Place the plates in hot water to which has been added 1 ounce of hydrochloric acid to the gallon, or in that proportion, and let them soak for an hour; after which put them in clean hot water for the same length of time and they are then ready to be placed in the rack to dry. After the plates are perfectly dry roughen the edges of the face of each plate by rubbing with an emery stick. The face of the plate is the side on which the gelatine is to be poured, and the edges thus roughened will prevent the gelatine from frilling when it begins to set. The next step is to prepare the gelatine.

Soak ¼ ounce of pure gelatine in 5 ounces of water; put the mixture in a glass bottle, and immerse in hot water, at a temperature of about 120° until melted; strain through a clean muslin cloth, rebottle, and again immerse in hot water to keep the gelatine at the required temperature of 120°. Now warm one of the plates, and rub the face with a piece of chamois to remove all particles of dust; place the plate, face upwards, on the fingers and thumb of the right hand, and, with the left, pour from the bottle about a tablespoonful of the gelatine for a 5″ × 8″ plate. Incline the plate from side to side until the entire surface is covered with the gelatine; then place on a level board until the gelatine sets. It is a good plan to mark the face of the plate in one corner, as it is difficult to distinguish the gelatined side when dry.

Plates that have been exposed but not developed, those that are "light-struck," and those that are unexposed will not require the gelatine process, but should be "fixed" in the usual way; that is, by soaking them in hyposulphite of soda, and then washing and drying. The making of the blueprint solution must now be considered. Dissolve in a bottle 120 grains of citrate of iron and ammonia in 1 ounce of water; in another bottle dissolve 80 grains of ferricyanide of potassium (red prussiate of potassium) in 1 ounce of water. Strain each solution separately, and mix eqnal parts of each. This mixture must be used at once, as it is worthless after standing for two or three hours. By gaslight, put this solution in a tray; place the plate face downwards in the liquid, and be careful not to allow the solution to run over the back of the plate. Hold the plate in this position for two or three seconds, and then dry in the dark.

These plates are now sensitized and, if kept perfectly light-tight, will last for about two weeks. In printing, treat each plate as if it were a sheet of blueprint paper, placing the film side down on the negative from which a transparency is to be made. When printing from a thin negative in the bright sunlight, place a piece of white tissue paper over the printing frame, to subdue the light; but when using a dense negative this will not be required. Print until the plate becomes a dingy yellow color, then remove the plate and wash thoroughly.

When mounting the transparencies thus made place the rough surface of a piece of ground glass against the film side of the transparency. This gives protection to the film and furnishes the necessary background to the picture. Stereopticon slides may also be made from these transparencies by the use of yellow transparent paint. This paint should be applied on the cover glass wherever a green effect is desired in the picture.

After the paint is dry, place the film side of the plate and the painted side of the cover glass together, bind them with ordinary gummed paper used for this purpose, and the slide is ready for use. If these directions are carefully followed the results will be most pleasing.

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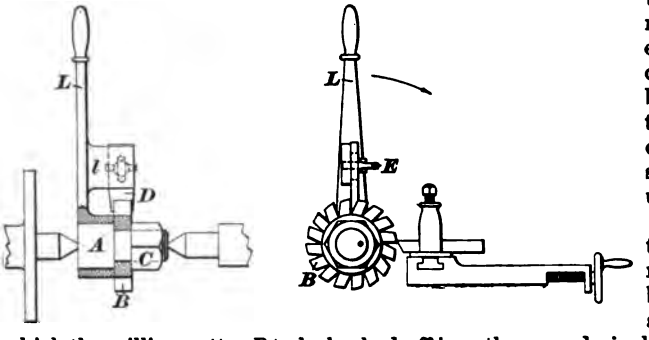
USEFUL IDEAS

AN INEXPENSIVE BACKING-OFF TOOL

Geo. Frederichsen, Chicago, Ill.

THE FOLLOWING method for backing off milling cutters, although necessarily slow, is very satisfactory and recommended for small tool rooms, where machinery is limited to a lathe and milling machine. The method is simply the use of the lathe as a shaper, so to speak, and requires a simple tool, consisting of the following parts: a mandrel *A*, upon



which the milling cutter *B* to be backed off is firmly held by a nut *C*. The centers of the mandrel are not in line with its axis, so that turning the mandrel with cutter on it, on the lathe centers, it will throw. A lever *L* is the other piece of the mechanism. This lever has a projection *l*, upon which slides a slotted piece *D*, held in position by a thumbscrew *E*. By depressing the piece *D* down between two teeth of the cutter and tightening *E*, the whole arrangement is made one piece, and by turning the handle of lever *L* in the direction of the arrow, one tooth may be backed off. After this the piece *D* is inserted one notch farther and the second tooth backed off, and so on.

TRANSFORMER TESTING

W. E. Wolfenden, Salem, Va.

I HAVE found by experience that it will pay any lineman or superintendent of a central station to test every transformer immediately before placing it in circuit on a pole. The following tests I have found to be sufficient and easily carried out: First, connect the wires of a magneto to the two primary terminals; if the magneto rings, disconnect one of the wires, and place it against the transformer case; if the magneto rings again, the primary coil is grounded on the core, and should not be placed in circuit.

The secondary winding should then be tested for continuity and insulation, just as the primary was tested. If it is in good order, connect one terminal of the magneto to one of the primary wires, and the other to one of the secondary wires. Connected thus, the magneto should not ring; but if it does, it is evident that there is a breakdown in the insulation between the primary and the secondary. In this condition, the transformer should, of course, not be used.

I found in one case that the wire from coil to connection block had been broken in transportation, and in another case one of the secondaries had come loose. Had I tested them before placing them on the pole I would have been saved considerable trouble.

A FROG PROTRACTOR

Theo. P. Perkins, Lynn, Mass.

DRAFTSMEN in railway offices spend much time making designs for "track layouts" of various kinds, such as passing tracks, coal tracks, passenger-car storage, freight-classification yards, etc. This is a condition that will prevail more and more, because the habit of trying things on paper before building them is gaining ground in nearly every department of constructive industry; often from two to four different designs for the same yard will be made for the powers that be to choose from.

In making such designs, it is necessary to lay off a great many frog angles, as every turnout has its frog. Where the track is straight it is an easy matter to lay out the frog, but where it is curved some ingenuity is necessary; the tangent must first be found and the frog angle laid off from that. As the work requires many repetitions of laying

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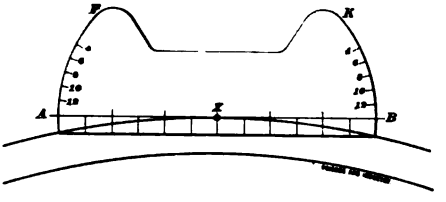
off the same angles, it calls for a labor-saving device, and here it is:

Take a piece of transparent celluloid—"amber" they call it at the stores—thick enough to keep its shape. Scratch the line *A B* a quarter of an inch or so from one straight edge, and parallel with it, as shown in the figure. Divide this line into some even number of equal parts, by short cross-lines, and, from the central point *X*, strike two arcs *A F* and *B K*, using the same radius for both. Cut the celluloid on these arcs, and then lay off, from the two ends of the line *A B*, using the point *X* as the angle point, the proper angles for the frog numbers desired. Five are shown on the sketch, the angles being somewhat exaggerated. Some would want more, but the tendency



seems to be to get along with as few standard frogs as is practicable. Number these lines with reversed figures, in order that the numbers will read aright when the graduated side of the protractor is placed contiguous to the paper. Finish the remainder of the celluloid strip to taste, removing most of the useless material.

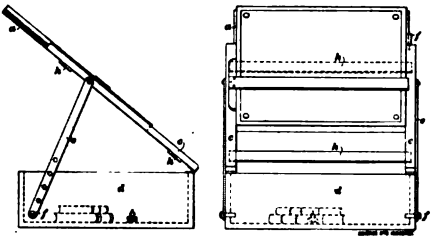
The accompanying drawing shows how to use it on a curved track. Set the point *X* over the proposed frog point on the plan, and swing the protractor until the line *A B* becomes tangent to the curve, which may be determined by noting when the offsets, from the line *A B* to the curve at equal distances from *X*, are equal. Hold it in this position while you make a pencil mark or needle hole at the proper point on the arc, then draw a line from this point to *X*, which line will represent one side of the frog. The manner of using it on a straight track requires no explanation.

A CONVENIENT DRAWING BOARD

V. C. S., Canton, Ohio

I OBSERVED in SCIENCE AND INDUSTRY, January, 1900, an account of a cheap drawing board, and along the same lines I beg to offer the following sketches and explanation of a board that might be useful to a student, because it can be folded up and put in a corner when not in use. This board can be adjusted to any angle, which enables the draftsman to avoid the tiresome and unhealthful position necessary when drawing on a horizontal board.

I took a common 17″ × 21″ drawing



board and nailed a strip of wood *a* along each end. Two pieces *c* are grooved to fit over the strips, and do not extend up far enough to interfere with the T square. The grooved strips *c* are fastened together with the braces *h*, and each is provided at the bottom with a hinge fastening it to the box *d*. This box serves both as a solid base and as a receptacle for books, inks, and drawing instruments. The board is adjusted and kept in place by the iron bars *e*, which are fastened to the strips *c*, and are provided with holes that fit over projecting pins in the side of the box *d*. The board is kept from sliding too freely in the grooves by means of a wedge at *f*.

NAILING INTERIOR TRIM

J. R. S., Stonington, Conn.

THE METHOD I use to nail or screw interior trim so as to hide the nail heads, while not a novelty, may be new to some. Where the nail or screw is to be placed I raise the wood with a sharp gouge, as in the accompanying sketch, and drive the nail or screw home, then fold the chip back in place and secure it with glue. If the job is properly done, it is almost impossible to detect the place where the wood was disturbed.

[This method can be employed very successfully in the shop, where the glue can be applied hot, but cannot be recommended in

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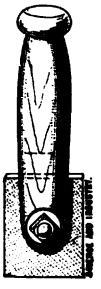
the building, as the glue is liable to chill before it can be applied, unless a specially prepared glue is used.—ED.]

HOLDER FOR INK ERASER

H. M. Chadwick, Malden, Mass.

A VERY cheap and effective holder for an ordinary Faber ink eraser can be made from a common clothes-pin by cutting down the legs to within about 2 inches of the end of the slot, and bolting the eraser between the two stumps with an ¼-inch bolt having a washer on each end. Drill the hole with a twist drill, to avoid splitting the wood. Any draftsman has but to try this scheme to become convinced of its superiority to the every-day thumb-and-finger method of holding the ink eraser.



A COMBINATION SCRATCH AWL AND KNIFE

J. W. Wolfenden, Nashville, Tenn.

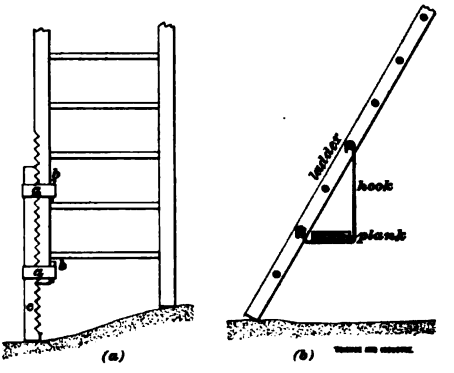
I SEND you a sketch of a useful little tool that I made for myself, hoping that it might interest readers of your Useful Ideas column. Every woodworker knows that he can make a cleaner line across the grain of wood with a knife edge than with a scriber point. He also knows that it is somewhat difficult to get a knife blade to follow a straight edge when he is marking with the

grain, and, in that case, he would use a point. As the drawing shows, this tool is always ready for use in either case, and it is also handy as a bench knife. The steel is of one piece and extends through the wooden handle. A screw might be provided, if necessary, to secure the blade from slipping through the handle.

AN ADJUSTABLE LADDER AND FIXTURES

A. C., Santa Rosa, Cal.

SOME of your readers may be interested in the adjustable ladder shown in the accompanying sketch. In working around a building, it is often necessary to block up one leg of a ladder to make it set plumb—an operation that is often far from satisfactory to the man whose duty it is to mount the ladder. A good device that will do away with this necessity is shown at (*a*) in the accompanying illustration. The side of the leg and the extension piece *c* are either notched or provided with iron racks. The extension leg is placed at the desired length



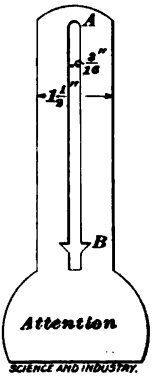
and clamped by means of wedges *b* inserted under the bands *a*.

At (*b*) is shown a steel hanger to be suspended from the rounds of a ladder; this provides support for a plank running parallel to the rounds of the ladder.

BELL-CALL INDICATOR

James P. Lough, New York, N. Y.

THE following idea, though extremely simple, is quite effective in attracting attention to telephone calls in busy and noisy offices, or where a number of telephones are placed side by side, as in the New York stock exchanges. Take a piece of stiff white cardboard about 7 inches long and 4 inches wide, and cut into the shape shown in the illustration. Cut a slot $\frac{3}{16}$ inch wide and about 5 inches long. At *B* two notches are indicated, which are to be cut as shown, the opening being large enough to slip over the hammer of the telephone bells. Now remove one of the bells and slip the cardboard drop over the hammer and replace the bell. To set the drop, lift it far enough to cause one of the notches to rest on the hammer arm. This will put the drop in a position not truly vertical, and when the bell is rung the drop will fall and indicate that the bell has been rung.



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EDITORIAL COMMENT

SOUVENIR PACKING TOOL

WITH ALL orders received during the month of March the Mound Tool and Scraper Co., 712 Howard Street, St. Louis, Mo., are giving a neat souvenir packing tool. They will also be pleased to send their circular to any interested in tools who will send their address.

THE COLUMBIA X CALIPERS

E. G. SMITH, Columbia, Pa., has gotten out a new design of his well-known calipers that appears to be a signal improvement. Instead of employing the usual thumbscrew for fastening the sliding head in position, he uses a small eccentric and suitable lever placed in the most advantageous position. This change makes the calipers very convenient for the pocket, as it incidentally reduces their size. Besides, there is no screw to be lost, or to catch when taking the calipers out of the pocket.

ANNIVERSARY NUMBER

WE HAVE received the special anniversary number of "The Blacksmith and Wheelwright," issued in celebration of its twentieth anniversary. This issue is a very creditable production, and full of good matter from cover to cover. While devoted primarily to the interests of the blacksmith and wheelwright, a few judiciously selected articles on matters of more general interest add greatly to the value of this issue. Having lived one score of years, we wish that our contemporary may attain to the full Biblical span of life, three score and ten, and more.

SELF-CLOSING DOORS

THREE objections have combated the more general use of self-closing doors; viz., appearance, first cost, and the cost of maintenance of hardware necessary to properly equip them. The luxury of such doors is self-evident, but, in public and office buildings where there is a great deal of traffic, they have become a necessity. There is also a growing demand for them in household service, so that every improvement that offsets the primary objections is welcomed. We note that The Easy Spring Hinge Company, of Shelby, Ohio, is now ready to put on the market a double-acting spring hinge that bids fair to meet with much favor among architects, contractors, and builders. The meritorious points in the easy-spring hinge are its simplicity of construction, ease of application, and reasonable cost. A door can

FIG. 1

be hung on this hinge as quickly as on a pair of common butts, and if the door does not register, that is, stop in the center, it can be adjusted by a setscrew without being taken down. The tension of the spring is easily regulated by a screwdriver. One of the principal advantages of the hinge is that, owing to its construction, the outer

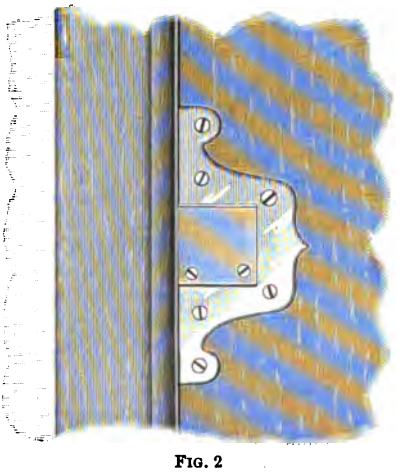

FIG. 2

edge of the door, without being rounded, can be fitted tight against the jamb, making it especially desirable for dining-room doors by preventing the entrance of fumes from

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the kitchen. It is claimed that outside doors hung on this hinge will not blow open. The door will not sag, nor will the hinges squeak. The hinge is made with or without a device that holds the door when fully opened, and it requires but the slightest touch to start it to shut when thus held open. The door will not pass the center when it springs back in place. Fig. 1 shows a section of a door stile and a jamb with the parts of the easy-spring hinge attached; in Fig. 2 is shown the hinge complete, with the cover-plate on the door stile, which gives a clear idea of the neatness and compactness of the appliance. The easy-spring hinge is made in many styles and in all sizes, and should be seen to be appreciated.

BOOK NOTICES

STEAM-ENGINE THEORY AND PRACTICE. By William Ripper, Professor of Engineering in the University College of Sheffield. Longmans, Green & Co., London, New York, and Bombay. Price, $2.50.

This book was written primarily as a textbook for the use of college students, and the author assumes that the reader has had the usual undergraduate training in mathematics and mechanics. The greater part, however, is so written that it can be easily read by any one having a knowledge of the elementary principles of algebra and trigonometry. The steam engine is considered as a heat motor, and the plan of treatment is a presentation of the theory of the various systems and devices for improving engine economy, together with modern practice in their application. In accordance with this plan, there are chapters on the thermodynamics of gases and the properties of steam; these are accompanied by an explanation of temperature-entropy diagrams and their application to problems pertaining to the steam engine. With these as a foundation, the theoretical advantages of compounding, superheating, steam jacketing, condensers, feedwater heaters, and various methods of governing are discussed, and their practical application explained and illustrated. This is done in a manner that will be interesting and instructive to the practical steam-engine designer as well as to the student of steam-engine theory.

The mechanical theory of the effect of the inertia of reciprocating parts on smooth running, balancing, and the action of governors and flywheels is given an amount of space commensurate with its importance to a work of this nature. A few of the leading modern English types of the steam engine, as applied to stationary, locomotive, and marine practice, are described, and serve as good illustrations of the practical application of the principles discussed. A few standard examples of modern engine details are also presented. These will serve a useful purpose as suggestions to students and young designers, but they will not be of much value to the practical designer of engine details. The author has drawn freely from recent articles and papers that have appeared in the technical press and in the proceedings of engineering and scientific societies. His purpose seems to have been to present the latest and most useful developments in the theory of the steam engine for the benefit of students of steam engineering. In this he has succeeded admirably; and has, at the same time, produced a work that will be a valuable addition to the practical steam-engineer's library.

THE METRIC SYSTEM OF WEIGHTS AND MEASURES. Issued by the Hartford Steam-Boiler Inspection and Insurance Company, Hartford, Conn. 196 pages, 3½ in. × 5¼ in. Price, $1.25.

It must be sorrowfully confessed that very little success has hitherto attended the efforts made to deliver us from what Lord Kelvin justly describes as the brain-wearying and intellect-destroying system of weights and measures in use among English-speaking people. In our domestic affairs we may persist in refusing to adopt the metric system as long as we please, but our trade with nations that use metric measures is steadily increasing, and, in manufacturing articles for this trade, we have no option but to use these measures. Moreover, the metric system is used in nearly all foreign scientific publications, and is being more and more employed in the best English and American books. Under these circumstances, a set of tables for reducing metric units to their American equivalents is almost indispensable. The very convenient pocket volume under review is most admirably arranged for facilitating these necessary reductions, and will prove an invaluable *vade mecum* for engineers and other scientific workers. The fact that the tables have been computed by Mr. A. D. Risteen, associate editor of "The Locomotive," is a sufficient guarantee of their trustworthiness.

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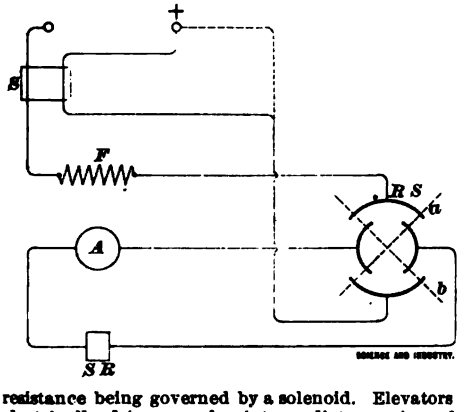
ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*
2. *Only questions of general interest to our readers will be answered.*
3. *No questions will be answered by mail.*
4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*
5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer*
6. *Reference to inquiries previously answered should give date of issue and number of question.*
7. *Questions cannot be answered in the issue of the month immediately following their receipt*
8. *Any book not out of print and for sale by regular dealers may be ordered through the magazine.*

(71) Please give a diagram for connecting electric elevator motors. R. B. P., Washington, D. C.

ANS.—In direct-connected elevators, the motor is usually of the series type; that is, the armature and field are connected in series. In starting the motor, to raise the car, the current must be prevented from attaining an abnormal value. This is done by inserting a rheostat in the circuit, the cutting out of



resistance being governed by a solenoid. Elevators electrically driven employ intermediate gearing of the worm pattern. This puts a bar to driving the motor by the descent of the elevator. Consequently, a simple reversing switch can be used in connection with a starting rheostat, as before described. A sketch showing connections for a worm-geared elevator, in which the reversing switch is operated by means of a rope, is shown here. *A* is the motor armature; *F*, the field; *R S*, the reversing switch; and *S R*, the starting rheostat. If the rope method of control is objectionable, the reversing switch can be fitted with a pair of electromagnets operated by push buttons in the car. Reversing switches are so constructed as to reverse the armature connections with a movement of the switch through 90°. This is indicated in the diagram. The contact brushes on the switch are to make contact between one of the inner segments and one of the outer. In position *a*, that terminal of the armature connected to — side of line is placed in connection with + side of line in position *b*. The starting rheostat *S R* is of the ordinary type, but so constructed as to allow its arm to be operated by a solenoid. The latter should be so connected as to be energized when the circuit is closed, that is, to the motor side of switch *S*. This switch may be incorporated in the reversing switch.

* * *

(72) What horsepower will it require to drive a boat 25 ft. long and 5 ft. beam, having a draft of 19 in., at a speed of 4 mi. per hr. through still water? F. H. B., Maysville, Ky.

ANS.—About two-thirds of a horsepower.

* * *

(73) Where can I subscribe for the following journals: American Engineer and Railroad Journal, American Chemical Society, Chemical News, Journal Institute Mining Engineers, American Chemist, American Chemical Journal. W. W., Emporium, Pa.

ANS.—All the above may be ordered through The Technical Supply Co., Scranton, Pa., or from the publishers direct.

* * *

(74) The appended sketch shows how our Penberthy injector is connected. This injector will not feed with less than 40 lb. steam pressure. (*a*) Is there any advantage in raising the tank above the level of the injector? (*b*) What is the lowest pressure that will operate it? (*c*) Would the substitution of straight-way valves for the globe valves cause the injector to work with a lower pressure? (*d*) What horsepower motor is required for a motor cycle weighing about 500 lb.? (*e*) What strength of current and number of storage batteries are required? R. H. G., Chicago, Ill.

ANS.—(*a*, *b*, and *c*) We have submitted your questions to an expert of The Penberthy Injector Co., who advises us as follows: A very important item of information, namely, the temperature of the feed-water, has been omitted. Nothing would be gained by elevating the water supply above the injector if the water-supply pipe is perfectly tight and no air leaks exist anywhere. One bad feature of the piping is that the steam supply is taken from the regular steam main, instead of an independent connection being made to the highest point of the boiler to insure a steady supply of dry steam. If this change is made, and the water supply is not above 74° F., the injector will start at 20 to 25 lb. pressure. Straight-way valves would be a detriment in this case, as it is not possible to satisfactorily throttle the water supply that is necessary on pressures below 60 or 65 lb. If the injector has been in use for a long time it may need new jets, or it may be partially stopped up with lime sediment. Of course, while in this condition the injector will not operate satisfactorily. (*d*) You would probably require a motor of about 1½ H. P. capacity. (*e*) If you run your motor at 80 volts, as is usually done, you would need a battery capable of giving a full-load discharge rate of at least 20 amperes. About the smallest standard battery made for this purpose would weigh 10 lb. per cell, making 400 lb. as the weight of the battery. We do not see, therefore, how you are going to have the total weight not exceed 500 lb. unless you use a lighter motor and battery than is customary.

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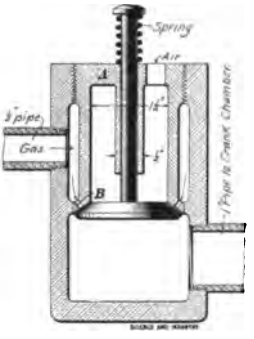
(75) How many, and what size holes should there be through *A*, and also through *B*, to give the proper proportions of air and gas for a 2-cycle gas engine, the cylinder being 4 in. × 4½ in.; feed-pipe to crank-chamber, 1 inch in diameter; and gas at 6-ounce pressure? V. E. F., Akron, Ohio.

ANS.—The proportions of the gas and air passages will depend on the quality of gas used. Probably 10 to 14 parts of air to 1 of gas will be the proper ratio. We should make the combined area of the holes through *A* about equal to the area of the 1-inch pipe. Five $\frac{7}{16}$-inch holes should be about right. With the ratio of gas to air given above, the combined area of the holes through *B* may be about ½ of the area of the 1-inch pipe. Eight ¼-inch holes will satisfy this requirement. It must be understood that the quality of the gas has considerable influence on the area of the gas passages. Passages amply large for rich gas may prove too small for poor gas.



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(76) (*a*) Please give the formula used in calculating the necessary number of turns on a choke coil having an open magnetic circuit. (*b*) What effect has the earth's magnetism on the readings of a voltmeter or ammeter? (*c*) How can I find the amount of power expended in the core of a choke coil having an open magnetic circuit? (*d*) Why are the armature coils in a Thomson wattmeter changed to a position at right angles to the plane of the fixed coil by means of the commutator? (*e*) Please give a formula for finding the magnetic flux in a transformer due to the primary turns.

G. V., Rose Bank, N. Y.

ANS.—(*a*) If *A* is the cross-section of the iron through the coil and *B* the magnetic density, then $B \times A$ is equal to the total magnetic flux *N*. A fair value for *B* would be about 20,000 lines per square inch. The number of turns on the choke coil would then be $T = \frac{E \times 10^8}{4.44\, N n}$, where *E* is the counter E. M. F. the choke coil has to generate, *N* the flux as obtained above, and *n* the frequency of the alternating current in cycles per second. (*b*) The earth's field has no appreciable effect on the readings of a modern voltmeter or ammeter. In instruments of the Weston type the coil swings in a strong magnetic field produced by permanent magnets, and this field is not changed appreciably by changes in the earth's field. (*c*) The best way to find the power expended is to use a wattmeter having its potential coil connected across the terminals of the choke coil and its current coil connected in series with the choke coil. (*d*) The Thomson wattmeter is in reality a small electric motor, and the commutator keeps changing the connections of the armature coils so that they always tend to rotate. The principle of operation is the same as that of a continuous-current dynamo or motor with a drum-wound armature. In this instrument there is no iron in the field, but this only makes the field weaker and does not change the principle of its action in any way. All the coils in such an armature are in action and the commutator serves to keep the direction of the current in the coils in the proper relation with regard to the field, so that continuous rotation results. If you read up any good description of the action of a drum armature you will have no difficulty in understanding the action of the wattmeter. (*e*) If the voltage applied to the primary is *E*, the number of primary turns *T*, and the frequency *n* cycles per second, then the maximum flux *N* will be $N = \frac{E \times 10^8}{4.44\, T n}$. This assumes a sine wave of E. M. F., and also that the counter induced E. M. F. in the primary is equal in value to the E. M. F. of the mains.

***

(77) Please explain how to determine the gears to be used on a stud and lead screw in order to cut 12 threads per inch in a single-geared lathe. Lead screw has 5 threads to the inch, gear on spindle has 21 teeth, and fixed gear on stud 42 teeth.

L. E., Middletown, Ohio.

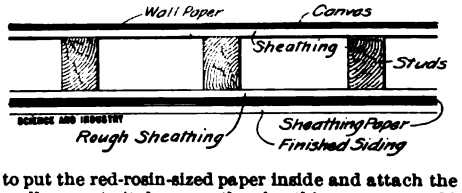
ANS.—The method of determining the gears was explained in the "Mechanics' Pocket Memoranda," and we refer you to that for a more extended explanation. We may say, however, that perhaps the easiest way of determining these gears is to remember that the product of the number of threads per inch to be cut, the number of teeth in the gear on the spindle, and the number of teeth in the change gear on the stud must equal the product of the number of threads per inch in the lead screw, the number of teeth in the gear on the lead screw, and the number of teeth in the fixed gear on the stud. We are obliged in all cases to assume the number of teeth in one of the gears that we are to find, and then, from the above relation, find the number of teeth in the other gear. If the number of teeth so found contains a fraction, or if we have no gear having the number of teeth found, we must try again by assuming a different number of teeth for the gear we started with. In the example given, suppose we represent the number of teeth in the change gear on the stud by *f* and the number of teeth in the change gear on the lead screw by *h*; then $f \times 12 \times 21 = h \times 5 \times 42$. Now, assuming that we have a gear containing 72 teeth, we have $f \times 12 \times 21 = 72 \times 5 \times 42$, from which we obtain, by division, $f = 60$ teeth; that is, the change gear on the stud has 60 teeth and the change gear on the lead screw has 72 teeth.

***

(78) I am erecting a frame house, and in this locality it is customary to rough-ceil the walls inside, and cover them with canvas upon which the wall paper is laid. Instead, I wish to use red-rosin-sized sheathing paper, and would like to know how it is put on, and what kind of a job it would make to put the wall paper directly on the sheathing paper.

O. P., Crockett, Texas.

ANS.—Red-rosin-sized sheathing paper is usually nailed in place, and makes an excellent protective material when placed between the rough ceiling and the finished siding. It would never do, in our opinion,



to put the red-rosin-sized paper inside and attach the wall paper to it, because the sheathing paper would expand with the moisture, and changes in temperature would cause buckles on the walls and sags in the ceiling; or, if it contracts much from excessive dryness or low temperature, it is liable to split and crack the wall paper. The best manner in which to construct the walls of the house, if the expense can

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be afforded, is to put rough sheathing outside and inside, placing the sheathing paper between the sheathing and the finished siding, and the canvas on the inside rough ceil, securing the wall paper to the canvas. A section of such construction is shown in the accompanying sketch. It would make a still better job to put a layer of sheathing paper between the studs and the inside sheathing, in which case strips must be nailed between the studs, to which the horizontal joints of the paper can be secured.

***

(79) (*a*) Is it not one of the recognized laws of mechanics that more work must be expended in operating any machine than can be received in return? (*b*) If this is true, how can we account for the fact that a person can cover a greater distance with a given effort on a bicycle than by walking? (*c*) We have a grinding machine in our shop the wheel of which has a velocity ratio of 22.5 to 1; that is, it should make 2,700 rev. per min. when the main shaft makes 120; its actual speed, however, is a little less than 2,400 rev. There are three belts between the main shaft and the spindle that carries the wheel; should there be that amount of loss in speed? (*d*) What rule can be used to calculate the percentage of loss for any machine?

W. W. B., Moberly, Mo.

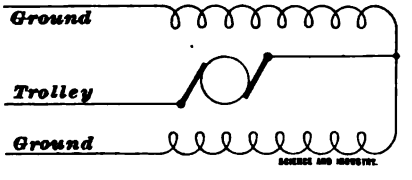
ANS.—(*a*) Yes. (*b*) The loss of energy in the rolling motion of the bicycle is less than the loss involved in the up-and-down motion of the person's body that takes place in the act of walking. A more detailed answer to this question will be found in SCIENCE AND INDUSTRY, February, 1900, Answers to Inquiries, No. 21. (*c*) Such an amount of loss might be expected under certain conditions. (*d*) We do not think a definite rule for calculating the loss in any case can be derived. The loss may be divided into two parts—the slip of the belt on the pulleys, and the "creep," or the effect of the difference in the amount the belt stretches on the tight and loose sides—which depend on such conditions as the length of the belts, the material of which they are made, the relation between their size and the power they must transmit, and the relative dimensions of the pulleys on which they run.

***

(80) (*a*) We have several Westinghouse 12A motors with the unventilated armature, and would like to use the forms for the ventilated armature to wind the coils for them. Can this be done? In the unventilated armature the coils span the first and the thirteenth slot, and, in the ventilated armature, they span the first and the eleventh slot. (*b*) We also have a motor connected as shown in the accompanying sketch. Is this a shunt or series motor?

A. F. R., Harrisburg, Pa.

ANS.—(*a*) It would be better to have a separate form for each armature, as this would insure more accurate fitting of the coils. You may, however, be able to fix two strips on the form, so as to widen it out enough to make the coil span the two extra slots. A strip on each side of the form would make



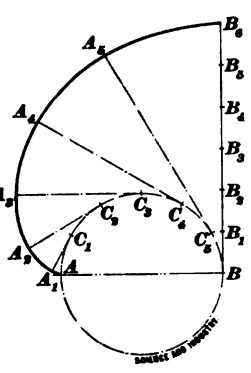
the opening wide enough to span the extra slots, and these strips could be removed when it was desired to make coils for the ventilated armature. We assume in the above that you are using the common trapezoidal form. With some styles of forms it might not be possible to add strips as we suggest. (*b*) The motor you refer to is series wound, the only peculiarity about it being that the two field coils are connected in parallel instead of in series, as is usually the case. The field winding is, however, in series with the armature, and the machine is therefore a series motor.

***

(81) Give a simple illustrated method of describing an involute of a circle.

D. G. D., Phillipsburg, Mont.

ANS.—Let $A\,B$ be a diameter of a circle; lay off, on the tangent at B, the length $B\,B_6$ equal to the semicircumference of the circle. Divide $B\,B_6$ into any number of equal parts, say 6, in the points B_1, B_2, B_3, B_4, B_5. Divide the semicircumference into the same number of equal parts in the points C_1, C_2, C_3, C_4, C_5, and draw the tangents at these points. On these tangents, lay off $C_1\,A_1$, $C_2\,A_2$, $C_3\,A_3$, $C_4\,A_4$, $C_5\,A_5$ equal, respectively, to $B\,B_1$, $B\,B_2$, $B\,B_3$, $B\,B_4$, $B\,B_5$.



The curve passing through the points A, A_1, A_2, A_3, A_4, A_5, B_6 is the required involute.

***

(82) What has produced the best results in reducing water friction on ships' bottoms? Is there any record of recent tests, and, if so, where can I procure them?

R. J. K., New York City, N. Y.

ANS.—Full information on this subject can be had by writing to the "Queries and Answers" department of "Marine Engineering," published monthly by Aldrich & Donaldson, 309 Broadway, New York City.

***

(83) How is the Greek alphabet written in ordinary handwriting?

P. A., Media, Pa.

ANS.—See "The Mechanic Arts Magazine," September, 1899, Answers to Inquiries, No. 224. The written characters are very much the same as the printed ones, without any attempt at joining the letters.

***

(84) Explain the instrument used for recording the vibrations of an earthquake.

W. H., Alameda, Cal.

ANS.—Such instruments as you mention are very few in number, and are to be found at the great observatories only. For information in regard to these instruments, we would advise you to write to Mr. C. D. Perrine, of the Lick Observatory, Mt. Hamilton, California.

***

(85) I am building a house, and the plastering already shows cracks lengthwise of the lathing. (*a*) Can you tell me what is the cause? The lath was dry and had been on the wall for a year, and it was not dampened before plastering. (*b*) Do you think lightning rods are a benefit to a building? Will they prevent it from being burned by lightning?

M. L., Shepherd, Mich.

ANS.—(*a*) The lathing should have been dampened before the plastering was applied. Where the lath is very dry, it extracts the valuable moisture too rapidly from the plaster and causes it to crack. Plaster mortar should be thoroughly mixed so as to make it tough; when improperly mixed, it shrinks

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more in drying and causes cracks. "Elbow grease" is what is wanted, both in the preparation and in the application of the mortar, and sufficient hair should be incorporated in the "scratch," or first coat. (*b*) Lightning rods are a protection to a building when they are of proper size and correctly installed. An article on this subject appeared in the December, 1898, issue of "The Building Trades Magazine." If the discharge of the electric current can be transmitted promptly to the earth by the rods, no fire is likely to ensue, although the lightning sometimes ignores the offer of conveyance by the rods, and takes a devious path of its own, when it rips, tears, and occasionally sets fire to objects resisting its progress.

***

(86) Give me a recipe for painting a blackboard. The material is redwood.

F. A. V., San Francisco, Cal.

ANS.—Give the board a good priming coat of white lead mixed with lampblack, and then two coats of drop black ground in japan, thinning with turpentine to obtain the dull flat finish. Allow at least three days between coats, to allow the paint to harden.

***

(87) (*a*) Is it necessary to have a license to sell chemicals? (*b*) Describe the process of photoengraving.

F. D. H., Jersey City, N. J.

ANS.—(*a*) So far as we know, no license is needed to sell chemicals, but a license is necessary to dispense medicines, prepare physicians' prescriptions, etc. All this varies in the different states, and is subject to state laws. (*b*) The process of photoengraving is too intricate to be fully described in these columns. Usually, a wet-plate negative is made from the drawing to be reproduced, from which is printed the picture in reverse on a zinc plate sensitized with bicromate of potash, and afterwards developed with a roller charged with lithographing transfer ink. After the print is washed out in water it is prepared with "dragon's blood," and etched in a dilute solution of nitric acid. In each successive etch, the plate is protected by "dragon's blood," applied in such a way as to produce a bank against the lines, preventing their being undermined by the action of the acid. After the final etch is completed the plate is routed and mounted ready for the press. A practical treatise, with working directions, is found in Farquhar's "Grammar of Photoengraving," Scovill & Adams, New York; and Jenkins's "Manual of Photoengraving," The Inland Printer Co., Chicago, Ill.

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(88) (*a*) It is stated that the force of gravity is proportional to the square of the distance. According to this statement, a body that weighs 4 lb. at a distance of 1 ft. from the surface of the earth should weigh 1 lb. at a distance of 2 ft. from the surface. As a matter of fact, it weighs practically 4 lb. Can you explain this to me? (*b*) The catch that holds the forearm to the barrels of my shotgun has become loose. Can you give me a simple method by which I can braze it on again? Part of my difficulty is the fear of injuring the barrels and of loosening the rib between the barrels. (*c*) The color of objects is the result of the rays of light they reflect, but, in the case of transparent or semitransparent objects, the transmitted light is the same color as the reflected light. Why is this?

L. R. P., Monte Creek, B. C.

ANS.—(*a*) Your statement is wrong. The force of attraction is *inversely* proportional to the square of the distance between the centers of gravity of the bodies. Hence, the weight of a body at the surface being known, its weight at any given distance above the surface is formed by multiplying the square of the radius of the earth by the weight of the body at the surface, and dividing the product by the square of the distance between the center of the earth and the center of the body. (*b*) The catch you speak of is usually fastened with ordinary soft solder, as is also the rib on top of the barrels. If the catch has been broken off, clean the surfaces thoroughly and tin them with a soldering iron. Place the catch in its proper position and fasten it with binding wire. Then, with the soldering iron, or any other hot piece of metal, heat the catch until the solder flows nicely. Do not use any acid for a flux, but a little powdered resin. (*c*) This phenomenon is due to the property of selective reflection and transmission; i. e., these transparent or translucent substances reflect and transmit in excess certain wave lengths of the light that falls upon them, and thus appear colored, and emit colored light when illuminated by white light.

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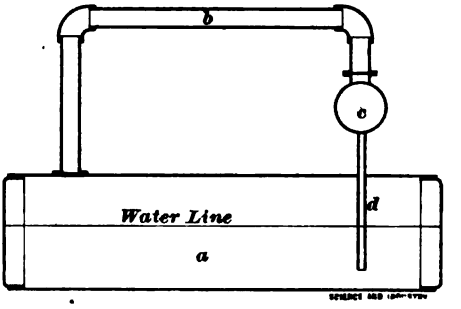
(89) (*a*) In my boiler plant, the boilers are connected to a header *c* in the manner shown in the illustration. A great deal of water collects in this



header and works into the engines and causes trouble. Can I remedy it by putting in the pipe *d* to drain the header, carrying it below the water-line of each boiler? (*b*) Give me a rule for throwing the tool head around when chasing threads: for instance, in cutting four threads to the inch, how many degrees should I throw the tool head around?

B. B., Throop, Pa.

ANS.—(*a*) We believe that the proposed drain pipes will work satisfactorily. (*b*) Your question is not clear. We suppose that you have one of the Stevens Arms Co.'s patent threading tools, in which the tool can be turned to an angle corresponding to the pitch. The proper angle can be found from the following formula, in which a = diameter of thread, and b = pitch of thread: $\frac{b}{\pi a}$ = tangent of pitch angle. For example, let $a = 1$ in., and $b = .25$ in. (4 threads per in.); then, substituting values, we get $\frac{.25}{3.1416 \times 1} = .079577+$. Looking in a table of natural tangents, we find the angle corresponding to this tangent to be 4° 33′.

***

(90) Explain the method of winding used on the armature of a 4-pole Westinghouse exciter with 47 coils and 47 segments on the commutator. This winding appears to be made upon a form and then laid on the core; but I do not see how to secure a symmetrical winding and commutation from an even number of poles and an odd number of bars. It appears to be a ring winding, but without any dead return wire. Am I correct? Would this be a good winding for a 1 K. W. motor?

J. F. B., Maquoketa, Iowa.

ANS.—The winding you refer to is a drum winding made up of formed coils, the ends projecting beyond the core of the armature. The odd number of coils is used in order that the winding may connect up

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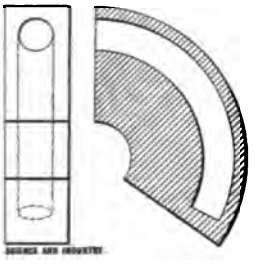
properly to form a two-circuit armature. In such a winding, commutation would not occur at exactly the same instant at all the brushes, but this does not affect the operation of the machine materially, because the number of sections is large. The winding is not of the ring type, although the core on which the winding is placed may be open through the center and have somewhat the appearance of a ring. If you will examine it closely you will find that the end connections of the coils project past the iron core, and that the winding is really of the drum type. This style of winding would answer quite well for a 1 K. W. motor, especially if it were of the 4-pole type.

***

(91) How can I bore a curved hole in a cast-iron block? The curvature of the hole and shape of the block is shown in the accompanying drawing. H. E. J., Downey, Cal.



ANS.—We believe this is a rather hard job; perhaps some of our readers may know how to do it. To us it looks like a case of bad design, and it seems scarcely possible that it could have been designed by an experienced mechanical draftsman.

***

(92) How can I construct a cheap bevel-edged picture-mat cutter and have it arranged so as to cut odd shapes either way from the perfect ellipse, and also to cut round bevel-edged mats?

G. H. W., Southbridge, Mass.

ANS.—Picture-frame and mat makers usually cut all curved shapes with a sharp knife freehand, after marking it out with a pencil. There is no machine on the market to do this work, so far as we know.

***

(93) An army is 25 mi. long, and marches 25 mi. per day. A messenger, starting from the rear when the day's march begins, rides to the front, delivers his message, and returns to the rear, which he reaches just as the day's march ends. How far did he ride? O. E. V., Dayton, Ohio.

ANS.—In the morning let the rear of the army be at A and the front at B; at the end of the day's march the front will be at the point D, such that $BD = AB = 25$ mi., and the rear will be at B. Let C be the point where the messenger overtakes the

$$A \qquad\qquad B \qquad\qquad C \qquad D$$

front. While the army marches 25 mi., the messenger rides 25 mi. from A to B and twice over the distance BC; that is, the officer gains twice the distance BC while the army marches 25 mi. Hence, the number of miles gained by the messenger while the army marches 1 mi. $= \frac{2 \times \text{No. of mi. in } BC}{25}$. Again, while the front of the army marches from B to C, the messenger rides from A to C, gaining 25 mi. Therefore, the number of miles gained by the messenger while the army marches 1 mi. $= \frac{25}{\text{No. of mi. in } BC}$

Thus, $\frac{2 \times \text{No. of mi. in } BC}{25} = \frac{25}{\text{No. of mi. in } BC}$; for each of these fractions = the number of miles gained by the messenger while the army marches 1 mi. When two fractions are equal, the product of the numerator of the first and the denominator of the second = the product of the numerator of the second and the denominator of the first. Therefore, $2 \times$ (No. of mi. in $BC)^2 = 25^2$. Hence, (No. of mi. in $BC)^2 = 25^2 \times \frac{1}{2}$, which gives, No. of mi. in $BC = \frac{25}{\sqrt{2}}$; whence, $BC = \frac{25\sqrt{2}}{2}$ mi. The distance ridden by the messenger is

$$AB + 2BC = (25 + 25\sqrt{2}) \text{ mi.} = 25(1 + \sqrt{2}) \text{ mi.}$$

***

(94) Give me a rule for estimating the heating capacity of a hot-air furnace.

A. C. B., Toledo, Ohio.

ANS.—We do not know of any rule for estimating the heating capacity of a hot-air furnace. It is evident that no rule can be formed that will apply to all furnaces, because the construction of the several kinds are so varied, and their methods of operation so different, that no permanent ratios can be adopted to suit all. We would, however, draw your attention to an article in "The Building Trades Magazine," March, 1899, number, entitled "How to Select a Furnace." This article contains a table of proportions generally adopted in furnace heating, and from this table you can obtain a very good idea of the size of furnace to do certain work. "The Building Trades Magazine" now forms a part of SCIENCE AND INDUSTRY, but back numbers can be obtained from The Colliery Engineer Co., Scranton, Pa.

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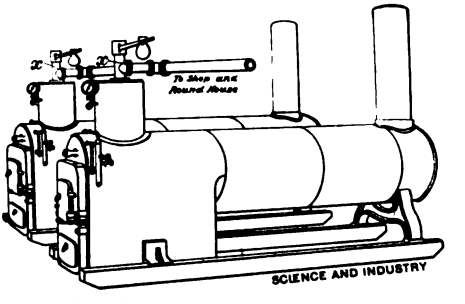
(95) I send herewith a sketch of two boilers that have attracted considerable attention on account of their being heavily charged with electricity. If the finger is placed near the boilers, a spark about ½ inch long will pass. The boilers are connected as shown in the drawing, and the connections at the steam domes are made by means of flange joints. Part of one of the gaskets blew out at the point x, allowing the steam to blow out across the other boiler. Both boilers are heavily charged, but by driving a plug in the broken joint, all the electricity disappears. Is there any scheme by which this electricity can be caught and made to operate a light, and what is the cause of the charge described above?

E. M., McMechen, W. Va.

ANS.—Under certain conditions, a jet of steam issuing from an opening will become electrified, and machines have been designed for the production of static electricity in this way. Both the jet of steam and the boiler become charged, one being positive and the other negative. The electrification is due to the friction of the globules of water contained in the steam passing through the orifice, and it has been found that wet steam gives a stronger charge than dry steam. Of course, as soon as the hole is plugged up the charge disappears, because there is no jet to



produce it. There is no practical method of operating a lamp from a source of electricity of this kind, because, although the electrical pressure produced is high, the quantity of current that could be obtained is so extremely small that a lamp could not be operated with it.

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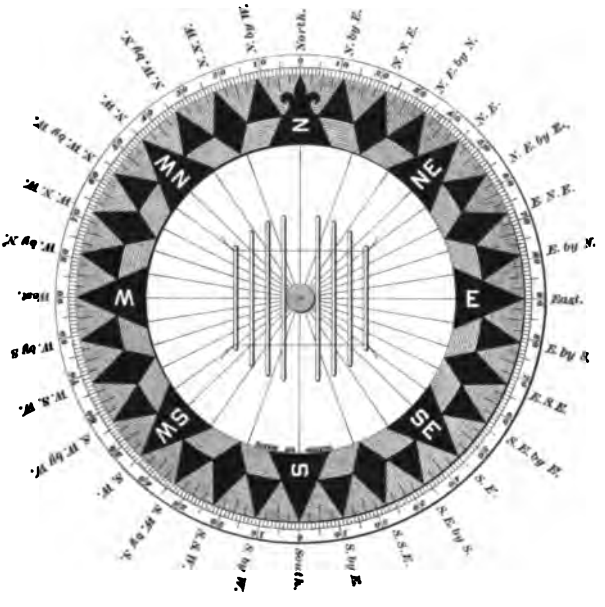
(96) Tell me how to read the points of the compass. T. N., Milwaukee, Wis.

ANS.—To read the points of a compass, or what is generally known as "boxing the compass," is easily learned by aid of the accompanying compass diagram. Beginning with the north, and going around in the same direction as the hands of a clock, the 32 compass points appear in the following order: North; north-by-east; north-northeast; northeast-by-north; northeast; northeast-by-east; east-northeast; east-by-north; east; east-by-south; east-southeast; southeast-by-east; southeast; southeast-by-south; south-southeast; south-by-east; south; south-by-west; south-southwest; southwest-by-south; southwest; southwest-by-west; west-southwest; west-by-south; west; west-by-north; west-northwest; northwest-by-west; northwest; northwest-by-north; north-northwest; north-by-west. Of these, north, south, east, and west are



called the *cardinal points;* and northeast, southeast, southwest, and northwest, the *intercardinal points.* Each point is divided into half and quarter points, which are named according to their location. Thus, the division to the left next to *N. N. E.* (looking from the center of the diagram) is read as N by E ¼ E; and the one to the right next to *S. W.* is read as S W ¼ W. Besides these divisions, the compass is divided into 360°; each point, therefore, contains 11¼°. A course when expressed in degrees is always reckoned from north or south 90° each way. Thus, N E is N 45° E, and S W is equal to S 45° W.

***

(97) (*a*) Would a safety-valve arrangement attached to fuel feed regulate the supply of fuel? (*b*) How could a similar arrangement be made to regulate the water supply to a boiler, so that the water could not get below or above certain given points, regardless of the pressure of the steam? (*c*) On what basis, or by what formula, is the horsepower of a rotary engine calculated? (*d*) At what temperature does gasoline become unsafe when flame does not come in direct contact with either the liquid or vapor? A. P., San Francisco, Cal.

ANS.—(*a*) Various devices for regulating a liquid fuel supply for a steam boiler to correspond to the demand for steam, have been made. In most of these devices, the steam acts on a diaphragm so as to compress a spring, the amount of compression depending on the steam pressure. The motion of the diaphragm regulates the amount of opening of a valve that controls the fuel supply. (*b*) We do not know of any method by which the water supply could be regulated by a device similar to that used for controlling the fuel supply. A simple, but not always reliable, method of controlling the water level in a boiler is by means of floats that open or close a valve as the water level falls or rises. (*c*) The only accurate method of ascertaining the horsepower of a rotary engine is by means of a brake test. The indicated horsepower may, however, be calculated approximately by the following rule: Multiply the theoretical volume in cubic inches of the steam that passes through the engine in one revolution by the net pressure of the steam in the engine; multiply this product by the number of revolutions of the engine in 1 min.; the quotient obtained by dividing the latter product by 396,000 will be the indicated horsepower of the engine. This rule assumes that the net pressure of the steam in the engine is constant, an assumption that is permissible for most rotary engines. There are two difficulties in the application of this rule: there is no easy and reliable method of measuring the net pressure of the steam, and it is not always possible to measure the theoretical volume with a reasonable degree of accuracy. The pressure can, in general, only be approximately estimated, by observing the gauge pressure in the steam pipe near the engine, and assuming the loss from back pressure and friction in ports in accordance with judgment and experience. The theoretical volume can be estimated quite accurately from a drawing of the engine. If no drawing is available, the volume can be measured by driving the engine slowly by water or oil and measuring the quantity used per revolution. Owing to the fact that it makes no allowance for leakage, this method will give only approximately correct results in most cases. (*d*) At atmospheric pressure a mixture of gasoline vapor and air will not explode unless brought in contact with flame or subjected to a temperature of from 1,000° to 1,200° F. At higher pressures, explosion may take place at lower temperatures.

***

(98) I thought of injecting kerosene oil, drop by drop, into a boiler, to prevent scale formation. Will this injure the boiler? W. J. K., Erie, Pa.

ANS.—Kerosene will not do any harm, except that, when used in too large quantities, it may cause foaming. Your proposed plan of introducing it is the correct one.

***

(99) (*a*) In the case of an ordinary dynamo, but a small percentage of the generated current is used to energize the field magnets; that is to say, out of a total of 10 or 15 amperes, only 1 ampere, perhaps, is necessary to energize the field. Will this proportion hold good when the fields have a very low degree of magnetization, say 500 lines per sq. in.? (*b*) With any given number of armature coils and commutator segments, what construction would be best to give a direct current as free as possible from minute variations in voltage? A unipolar dynamo does not

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give pressure enough, and commutator machines give a small but rapid fluctuation of current that interferes with experiments I am making. (c) I have a small ring armature. If I arrange four fields and four brushes, can I draw off two currents and keep them independent? I wish to vary one current without affecting the other; the two pairs of fields are, of course, independent.

O. R., Deer Lodge, Mont.

ANS.—(a) If the magnetization used in the field is very low, the proportion of current required for excitation should be even lower than that usually required, because a fewer number of ampere-turns would be needed to set up the lower density; and with a small number of ampere-turns, there would be plenty of room to put on an economical winding. (b) The only way we know of to reduce the fluctuations is to use a large number of armature coils and commutator bars. If you wish a perfectly steady current for experimental work, we would advise you to use a storage battery. Even if you had perfectly smooth commutation you would be troubled with fluctuations due to slight changes in speed. (c) It would not do to run a ring armature as you suggest. If the two fields were excited independently of each other, the chances are that one would be stronger than the other. This would set up unbalanced E. M. F.'s in the different parts of the winding, and give rise to local currents in the armature. A better way would be to excite the fields together, so that they would all be of the same strength, and have two separate windings on the armature connected to the commutator. Even with this arrangement it is questionable whether taking current from one winding would not affect the E. M. F. generated in the other, owing to the influence of armature reaction.

***

(100) (a) Tell me how to estimate the amount of current a 50 H. P. motor is taking when there is a 400-ampere shunt. There are 80 divisions on an ammeter, and the pointer indicates 85 divisions. (b) Could we use the same shunt with a 5 H. P. motor, or must we procure a smaller one?

A. S., Long Island City.

ANS.—(a) If the ammeter gives a deflection of 80 divisions with 400 amperes through the shunt, the current for a deflection of 85 divisions should be about $\frac{85}{80} \times 400 = 175$ amperes, assuming that the scale is proportional throughout. (b) It would not do to use another shunt with the instrument; the same shunt should answer either for large or small currents. Shunts should always be used with the instruments for which they are made, because their resistance has been accurately adjusted with reference to that of the instrument, and, if changed in any way, the readings of the instrument will be inaccurate.

***

(101) (a) Why is it that in drop-cord for incandescent lamps one wire is covered with cotton in each group of wires that together form the conductor? (b) In a field rheostat for a dynamo the resistances are fine wires embedded in enameled disks. These disks are lettered, 12 being marked M; 7, N; 6, O; 6, P; 4, T; 2, U; 3, W; 2, X; and 3, Y. Can you tell me what resistance each letter indicates?

H. G., Fernie, British Columbia.

ANS.—(a) This insulated wire is not used in all lamp cord, and it was probably used in the case you mention to meet some requirement while being manufactured. Possibly the addition of this wire made the others strand up in better shape, or perhaps the stock of bare wire was found to be running low and an insulated wire used instead. The use of this single insulated wire is, however, by no means general. (b) We have no means of telling the value of these resistances. Your best plan would be to write to the manufacturers of the rheostat.

(102) On a building that I am constructing there is a gable running into a conical-tower roof. Explain how the line of intersection between the two roofs can be found, both in plan and elevation.

J. A. W., New York, N. Y.

ANS.—In "The Building Trades Magazine," February and April, 1899, are articles treating on the intersection of a hip roof with a conical tower. The same method therein used applies to the present problem. In this case, the line $a'''\ a_3$, Fig. 1, page 141, of the February issue of the magazine named above, corresponds to the eave of the gable, while a line drawn through l and parallel to $a'''\ a_3$ would be the ridge line. The intersection on plan would be found precisely the same as the line $a_1\ d_2\ e_3 f$ is found. These magazines can be obtained from The Colliery Engineer Co., Scranton, Pa., for 10 cents per copy.

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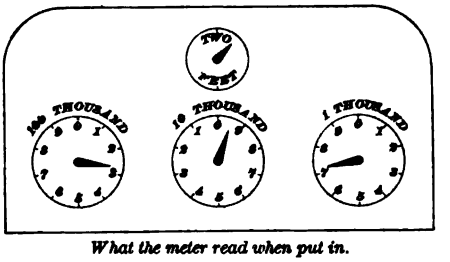
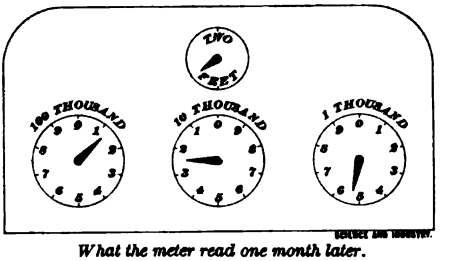
(103) In "Home Study Magazine," December, 1898, I read the article entitled "The Gas Bill," but it does not answer my case. When my meter was put in the house it read 29,700. It now reads 12,500. I have



What the meter read when put in.



What the meter read one month later.

been using the gas only a little over one month. (a) Will you or some of your practical readers explain why the meter reads this way? (b) Am I or is the gas company the loser if this reading is correct?

A. E., Buffalo, N. Y.

ANS.—We invite our experienced readers to help the inquirer out of his dilemma.

***

(104) We have 16 telephones (10,000 ohms) connected in series on a line 8 mi. long. The telephone-line wires are on the same poles with the electric-light lines and are transposed every 25 rd., but the induction from the latter lines interferes seriously with the use of the telephones. How can the trouble be overcome and the telephones still kept on one circuit, so that a switchboard will not be required? E. E. B., Johnson, Vt.

ANS.—You have so-called "series telephones," the resistances of the bells of which are from 80 to 120 ohms; the 10,000 ohms means that the generator is capable of ringing the bell through 10,000 ohms. You might first try placing the two telephone-line wires as near together as it is safe to put them without causing accidental crosses, and as far from the electric-light lines as possible without using a separate pole line; also, put your electric-light lines as close together as you can. However, unless you can

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also connect the telephones in pairs, one in each line at the same place, it is not likely that you can get satisfactory service with the telephones all in series; 16 telephones in one series circuit make a very bad arrangement under any conditions. A far better method would be to get regular "bridging" telephones, and connect them in multiple; this would remedy your trouble. Bridging telephones have high-resistance bells (500 to 1,000 ohms) and generators that should be powerful enough to ring all the bells when the telephones are connected in multiple. Bridging telephones are especially suitable, and are made by various telephone manufacturing companies for just such systems as yours.

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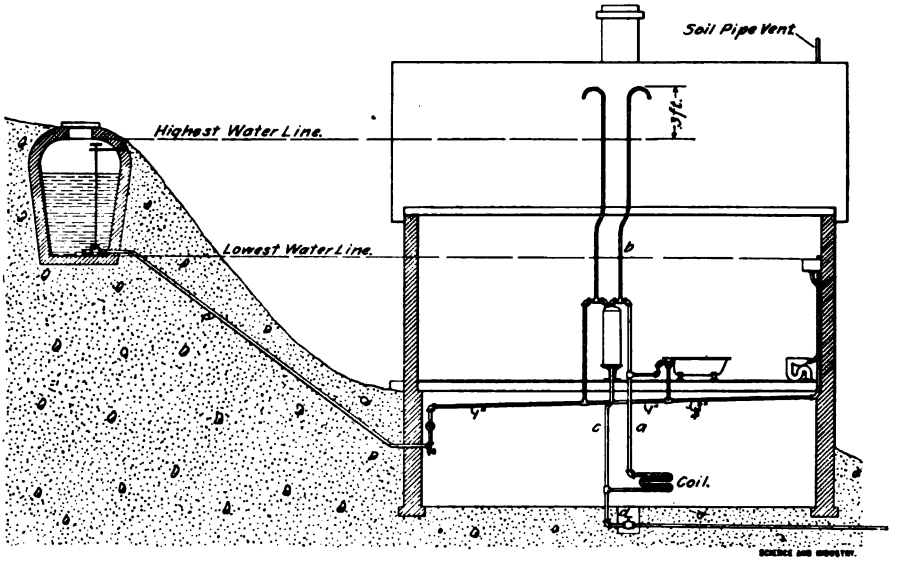
(105) I am building a house and want a supply of hot water in the bathroom, and also wish to heat this room by placing the hot-water tank in it. I will not have a stove except an oil one, and want to heat the water by means of a coil in the fireplace in the basement. The bathroom is on the floor above. There is a water closet in the bathroom, but no wash basin. (*a*) Could a coil placed in the basement fireplace heat the water in the hot-water tank? (*b*) What size should the coil be, and how would you connect it with tank? The water supply is to come from a cistern 7 ft. deep, the bottom of which is on a level with the top of the water-closet tank. (*c*) Will the pressure from the cistern be sufficient to work the water-closet tank? The house is being built on a hillside, and the cistern will be up hill from the house, about 25 ft. away. The sewer pipe runs down hill to a point 100 yd. from the house. (*d*) How would you dispose of the sewage?

C. R. S., Rome, Ga.



ANS.—(*a*) Yes. (*b*) The size of the coil, of course, depends considerably on where you locate it, and the kind of fuel you propose to burn. Assuming that the coil is located at the back of an ordinary coal fire, it would be safe for you to make it out of 1" copper pipe, having a surface of 1 sq. ft. exposed to the heat of the fire; 1 sq. ft. of surface is equal to 3 lin. ft. of pipe, and if the back of the fire is about 14 in. wide, 3 pipes deep would do the work. But you cannot count on the back surface of the pipes as very effective heating surface; therefore, we would suggest that you give the coil another pipe, to compensate for this. The pipes in this coil would be about 2½" centers, which would make the coil 8 or 9 in. deep over all. Connect the pipes as shown in the accompanying sketch; that is to say, run the cold-water pipe from the cistern direct to the boiler, in the ordinary manner, branching off for the bath and water-closet tank. Connect the upper part of the coil to a 1" galvanized-iron pipe *a*; continue this straight to the bath, pitching upward. Take off a ¾" branch to the bath; continue the 1" pipe up to the level of the top of the boiler and connect with an expansion pipe *b* as shown. Run another 1" pipe *c* from the bottom tapping of the boiler direct to the lowest opening of the coil, for circulation. Place a stop-cock on the sediment pipe at *d*, to blow off the boiler and coil when desired. Run this sediment pipe through your wall and let it discharge on the surface of the ground a little way down the hill. Place the stop-cock underneath the hearth, and you can use a loose tile or a small brass plate to cover it. Supply the boiler from above, with cold water from the cistern, in the ordinary manner, running a ¼" pipe up through the roof, to prevent air from accumulating at that point, and shutting off the supply. The expansion pipe *b* serves the same purpose on the hot-water pipe. This arrangement of circulation will furnish hot water to the bath as soon as it is heated in the coil. You do not have to wait for the boiler to heat, because the boiler in this system is simply a storage tank to take up surplus hot water. (*c*) Yes; the pressure will be strong enough when the cistern is full, but when it is nearly empty, the water-closet tank will fill too slowly. If you can raise the cistern another foot, you will obtain better results, and there will be no danger of the closet tank filling with the last dregs of the cistern. Run a 1" pipe from the cistern to the boiler, a ¾" branch to the bath, and a ¾" to the water closet. A ½" pipe is generally used for water closets, but the hydraulic head is so low that we think it is advisable for you to use a ¾" pipe. (*d*) The best method of disposing of the sewage depends on the locality. You seem to be well favored with conditions, because you can deliver it 100 yd. from the house. It will cost considerable money to run a 4" sewer pipe 100 yd., and

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since your house is in the country and the cistern so high on the hill, we would suggest that you make a leaching cesspool about 150 ft. from the house, down the hill, and run the sewer into that. Place a trap on your sewer pipe, just outside the cellar wall, with a fresh-air inlet attached. Run the soil pipe up through the roof, to a point 2 ft. above the ridge. Place a ventilating grating over your cesspool and you will have a pretty good job.

***

(106) We are running two 15 K. W. compound-wound Edison dynamos in series on the three-wire system; apparently, they are exactly alike. In the case of the positive machine it is necessary to shift the resistance in the shunt for every little change of load, in order to keep the potential constant, while with the negative machine it is only necessary to shift the resistance two or three times during the night, with a change from ⅛ to ¼ the load. Can you give a reason for this? B. H., Breckenridge, Col.

ANS.—It may be that the field magnet of the machine referred to is unstable; i. e., it is worked at such a degree of magnetization that small changes of field current produce wide changes in field strength and voltage. It might help matters to excite the shunt coils of the machine giving the trouble by connecting them across the terminals of the other machine, instead of allowing it to excite its own fields. Of course, there would be a field rheostat for each machine, so that the field current of each would be capable of independent adjustment, as before.

***

(107) (*a*) What is meant by using the term "solenoid," or what is a solenoid? (*b*) How can the size of copper wire be determined when used in connection with lighting work, the E. M. F. of the circuit being given, and also the candlepower of the lamps? Is the return wire taken into consideration? (*c*) How is the current delivered by an induction coil made alternating? (*d*) What is the resistance of copper wire?

F. W., U. S. S. Massachusetts, New York.

ANS.—(*a*) The term "solenoid" is usually used to denote a coil of wire of cylindrical form, the length of which is large compared with its diameter. The term also usually conveys the idea that the coil is not wound on an iron core, but is open through the center. (*b*) In addition to the voltage of supply and the size of lamps, you must also know the number of lamps, the distance from the dynamo to the lamps, and the percentage loss that is to be allowed in the line. The following formula may be used: Circular mils =

$$\frac{10.8 \times \text{double distance in feet} \times \text{current}}{\text{voltage} \times \frac{\text{per cent. drop}}{100}}.$$

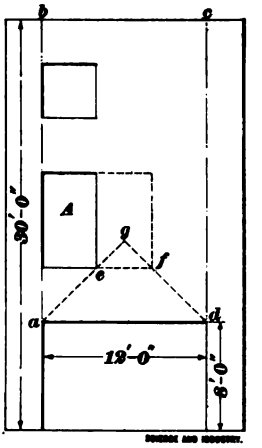
For example, required, the size of wire necessary to supply one hundred 16 c. p. 110-volt lamps situated 200 ft. from the dynamo. The allowable drop or loss in pressure is to be 2%. The current has to travel 200 ft. to the lamps and 200 ft. back, the total length of wire through which the current passes being 400 ft. The total current will be about 50 amperes, because one 16 c. p. lamp takes about ½ ampere at 110 volts. Applying the formula, we have: Circular mils $= \frac{10.8 \times 400 \times 50}{110 \times \frac{2}{100}} = 98{,}100$, approximately. We find by looking up a B. & S. wire table that No. 0 wire will have to be used. This wire has 105,534 circular mils cross-section, which is a little larger than required. (*c*) The primary circuit is interrupted by means of the contact maker, and this causes the magnetism in the iron core to increase and fall to zero every time the circuit is made and broken. When the magnetism is increasing through the secondary coil, it induces an E. M. F. in one direction, and when it decreases it induces an E. M. F. in the opposite direction, thus giving rise to an alternating current in the secondary. (*d*) The resistance of 1 ft. of copper wire $\frac{1}{10\,10}$ in. in diameter is about 10.8 ohms. For the resistances of various sizes of wire, consult any good wire table.

***

(108) What size I-beam lintel will be required to support the 18" wall as shown in the accompanying sketch? I wish to know what size beams will be required when the opening *A* is located as shown with the full lines, and when it is situated as designated on the sketch with dotted lines.

R. F. B., Sioux City, Iowa.

ANS.—If the lintel is supported from beneath while the wall is being erected, and the supports are left in place until the brickwork is set, the wall will naturally corbel, or arch, itself; and, with the opening to one side, as at *A*, or moved toward the center, as shown dotted, the amount of brickwork to be supported will be either the trapezoid *a e f d*, or the triangle *a g d*. In either case, two 6" 12-lb. beams will be ample, and, in fact, one would be sufficient; but in order to secure a good bearing for the wall it would be advisable to use two placed side by side. The best practice in a case of this kind, where the wall above the lintel is broken with several window openings, is to consider the lintel as supporting all that part of the wall included between parallel lines erected at its abutments. Considering the problem in this manner, the lintel in this case would support the portion of the wall *a b c d*, deductions being made for the window openings. The beams would then be somewhat heavier, and two 9" 21-lb. beams would have to be used. In determining the sizes of the preceding lintels, the floor joists or girders were assumed to be parallel with the wall, and, consequently, there was no floor load taken as coming upon the lintels.



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(109) I have a steam heater in my cellar, and have noticed that, when the cellar doors and windows are all closed, the damper weights have to be shifted from the position they were in when the cellar was open. If they are not changed then, the steam pressure will rise until the safety valve blows. Please explain. F. F. D., Worcester, Mass.

ANS.—There is only one apparent reason why your steam heater should act in this manner, and that is that the supply of air to the fire is not properly shut off when the air-inlet damper to the ash-pit is closed. There must be some very loosely fitting parts that allow air to get at the fire when everything should be shut off. When the cellar is closed, the pressure of the cellar air is lowered, and air does not flow so freely through the crevices and into the ash-pit then as it does when the cellar is open. The fire, therefore, will burn more briskly when the cellar is open than when it is closed, and steam is generated more rapidly when the cellar is open. In conjunction with the fluctuation of air supply to the fire, is the fact that the cellar is usually opened during mild

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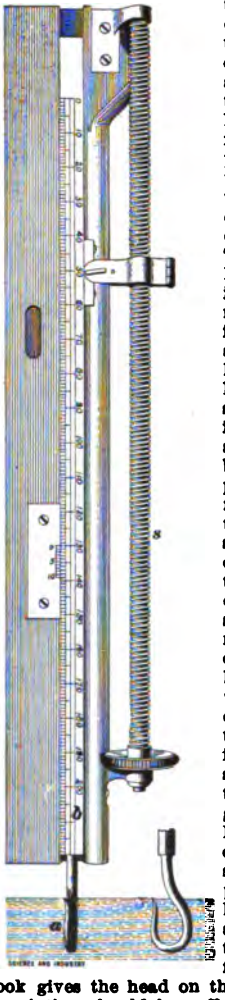
weather, and the radiators then do not condense the steam generated in the boiler as rapidly as they do when the weather is cold and the cellar closed.

***

(110) (*a*) Kindly describe a hook gauge and explain its purpose. (*b*) Please give a sketch with dimensions for a gauge that can be made for a 1-ft. or a 3-ft. length. C. H. W., JR., Boston, Mass.

ANS.—(*a*) A hook gauge is a device for making accurate measurements of the height of water. It is most often used in weir measurements, for finding the height above the crest of the water in the stream that flows over the weir. The accompanying figure, together with the following description, will make clear the principles of construction and the method of using the instrument: A hook *a* is attached to the lower end of a sliding scale *b*. The scale is graduated to hundredths of a foot, and is provided with a vernier by means of which it can be read to thousandths. The scale and hook can be raised or lowered by means of the screw *s*. The instrument is fastened securely to solid and substantial beams or masonry, at a point over the water a few feet up stream from the weir, and where the surface of the water is quiet and protected from the influence of wind or eddies. The gauge is set so that the scale will read zero when the point of the hook is at the same level as the crest of the weir. When the point of the hook is raised to the surface of the water, it lifts the surface slightly before breaking through. To use the gauge, start with the hook below the surface of the water and raise it slowly until a slight pimple, caused by the lifting of the surface, appears over the point; the reading of the scale for this position of the hook gives the head on the crest. (*b*) The above description should be sufficient to enable a skilled instrument maker to construct a gauge of any length.



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(111) (*a*) Is there a general rule by which the location of the brushes on a dynamo or motor can be determined, i. e., the position in which the brushes are to be set? (*b*) Can I get a book treating on the construction of electric and hydraulic elevators?

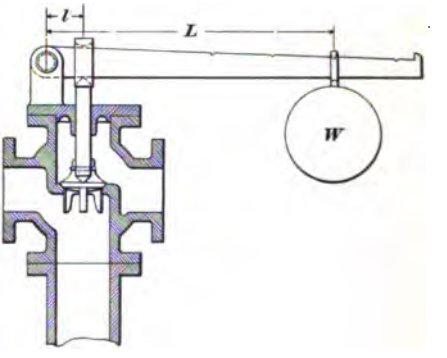
M. B., Watseeking, N. J.

ANS.—(*a*) In the case of a dynamo, the brushes should be set slightly forward in the direction of rotation from the neutral point. The neutral point is generally either in line with the center of the space between the pole tips or in line with the center of the pole piece, depending on how the armature connections are brought to the commutator. If the leads are brought out straight, the neutral point will be opposite the center of the space between the poles. If they are bent through an angle equal to half the distance between the centers of the poles, the neutral point will come opposite the centers of the pole pieces. In any case, the proper position for the brushes is at the point where there is the least sparking. When a motor is arranged so that its direction of rotation is reversed, the brushes must be placed at the neutral point. (*b*) We do not know of any book on this subject. Most of this information has appeared in various papers read before engineering societies. You might obtain the information you need from the two following papers read before the American Society of Mechanical Engineers at the Washington meeting in June, 1899: "The Plunger Elevator," by Geo. I. Alden; and "Elevators," by Charles R. Pratt. These papers may be obtained by writing to the secretary of the American Society of Mechanical Engineers, New York City.

***

(112) (*a*) Give a rough sketch of a simple engine-shaft governor, and state how it works. (*b*) Could it be used on a small engine—say about ½ H. P.? (*c*) How much should the ball of the steam safety valve shown in the sketch weigh, and how far should it be moved out to blow off at 50-lb. and 100-lb. pressure? (*d*) Does ¾" gas pipe measure ¾ in. inside diameter, or more? J. K., Cincinnati, Ohio.

ANS.—(*a*) The space in these columns is too limited for a comprehensive answer to this question. (*b*) Yes; but they are not generally used on such small engines. (*c*) You have not given sufficient data to



enable us to give you the required information. The distance L from the fulcrum may be found by the following formula: $L = \frac{(pa - w)l}{W}$, where p = blow-off pressure (100 lb. per sq. in. in your example); a = area of valve; w = downward pressure due to valve and lever, as measured by a spring balance attached directly over the valve stem; l = distance from fulcrum to valve stem; and W = weight of ball. As an example, suppose $W = 6$ lb.; $w = 2$ lb.; $l = 1$ in.; $p = 100$ lb. per sq. in. The inside diameter of the nipple being .67 in. (= outside diameter of ¾" pipe), $a = .7854 \times .67^2 = .35$ sq. in. Then we have $L = \frac{(100 \times .35 - 2) \times 1}{6} = 5\frac{1}{4}$ in. (*d*) Inside diameter of ¾" gas pipe measures .49 in. (nearly ½ in.).

***

(113) I have a dynamo, the armature of which is built up of laminations 3½" × 3". It has 16 slots, ¼" × ¾", and the commutator has 16 segments. The field core is 5" × 2" soft steel. The speed is 3,500

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R. P. M., and the armature runs within ¼ in. of the field. What sizes of wire should be used to make it light 4 lights, 110 volts, 16 c. p.? If you think it is too small to light 4 lights, give me the winding for 3 lights, or as many as you think safe without burning it out. N. G. B., Muscatine, Iowa.

ANS.—Wind the armature with No. 22 B. & S. double cotton-covered wire, using 72 turns per coil and 16 coils; this will make 144 conductors in each slot. Each coil will consist of 6 layers of 12 turns per layer. If you wish a series winding on the field, No. 16 wire should be used. We are unable to give the winding that should be used for a shunt field, as you have not given sufficient data. The winding as given above should be capable of delivering current for about 3 lamps.

***

(114) How can I make a small 4-pole dynamo of about 1 H. P. capacity? W. R., Allegheny, Pa.

ANS.—We cannot undertake to make calculations for dynamos or motors in these columns. Your best plan would be to get a book on the subject. There is a book published entitled "How to Make a One-Horsepower Dynamo," by A. C. Watson. This might give you the information you need, although we are not sure that the machine described is of the 4-pole type. Machines of such small size are usually built with two poles. The price of the above book is 50 cents, and it can be obtained from The Technical Supply Co., Scranton, Pa.

***

(115) What is the area of a triangle, the lengths of whose sides are 8 ft., 9 ft., and 10 ft.? T. J. D., Mt. Carmel, Pa.

ANS.—Let A equal the area, and a, b, and c the lengths of the three sides; then,

$$A = \frac{b}{2}\sqrt{a^2 - \left(\frac{a^2 + b^2 - c^2}{2b}\right)^2}.$$

For convenience, represent the 8-ft. side by a, the 10-ft. side by b, and the 9-ft. side by c; substituting these values of a, b, and c in the formula,

$$A = \frac{10}{2}\sqrt{8^2 - \left(\frac{8^2 + 10^2 - 9^2}{2 \times 10}\right)^2} = 38.68+ \text{ sq. ft.}$$

***

(116) (*a*) Explain how or why an incandescent lamp taking, approximately, ½ ampere at 112 volts can be called a 3.1-watt lamp. (*b*) Is the following solution of the accompanying rule correct? If not, explain. $\frac{3,600 \times \text{constant (if meter has one)}}{\text{watts in use}}$ = seconds per revolution of meter disk. Suppose we take four 16 c. p. lamps, requiring 60 watts each; this gives us $60 \times 4 = 240$ watts. The constant of the meter is ½. We then have $\frac{3,600 \times \frac{1}{2}}{240} = \frac{1,800}{240} = 7\frac{1}{2}$ sec. for each revolution of the disk; consequently, if the meter is correct, it will take 7½ sec. for the disk to make 1 rev. B. H., Breckenridge, Col.

ANS.—(*a*) The 3.1 watts refers to the watts required for candlepower. For example, if the lamp were of 16 c. p. and required ½ ampere at 112 volts, it would take a total of 56 watts, and the watts per candlepower would be $\frac{56}{16} = 3.5$. The number of watts per candlepower is a measure of the efficiency of the lamp, and, hence, lamps are often referred to in this way. (*b*) Your solution is correct.

***

(117) (*a*) Explain why an induction coil will not operate a small motor. The motor will run with the same cell that runs the coil. (*b*) Why will the coil not light a small series-lamp? W. J. S., Belleville, Ill.

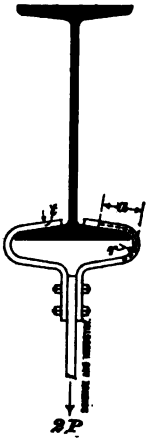
ANS.—(*a*) The coil will not operate the motor because the current delivered by it is alternating; i. e., it flows first in one direction and then in the other. The motor requires a direct current, such as that furnished by the battery. Another reason is that the volume of current delivered by the coil is very small, although the E. M. F. is high. The battery motor is wound for a small E. M. F., and a comparatively large current, so that even if the current were not alternating, it would, in all probability, not operate the motor. (*b*) It will not operate a lamp because the coil does not furnish a current of large enough volume to heat the filament.

***

(118) Explain how to calculate the strength of a hook to go over the flange of a 10" I beam, as per sketch. A. P. L., New Haven, Conn.

ANS.—The load P that each of the branches of the hook will carry for each inch of width may be calculated, approximately, by the formula:

$$P = \frac{St}{1 + \frac{a}{r} + \frac{6a}{t\left(1 + \frac{t}{2r}\right)}},$$



in which S is the allowable fiber stress per square inch of sectional area of the material of which the hook is made; t is the thickness of the plate from which the hook is made; a is the distance from a line drawn perpendicular to the flange of the beam through the point at which the hook is assumed to bear on the flange to a parallel line tangent to the curve whose radius is r; the length of the radius r of the curve to which the hook is bent is measured from the center of the curve to the middle line or axis of the hook. As an example of the application of this formula, we will assume the hook to be made of ½" iron having an allowable stress S of 10,000 lb. per sq. in. Assuming a standard 10" steel I beam, the distance a may be taken as 1 in., and the radius r as ⅞ in. Substituting these values, we have

$$P = \frac{10,000 \times \frac{1}{2}}{1 + \frac{1}{\frac{7}{8}} + \frac{6 \times 1}{\frac{1}{2}\left(1 + 2 \times \frac{1}{8}\right)}} = 108+ \text{ lb.}$$

The load per inch of width that the two branches of the hook will carry under the assumed conditions is $2P = 206$ lb.

***

(119) (*a*) I have heard of an electric gas igniter that does not require the house to be wired for its use. Where could I obtain information regarding this igniter? (*b*) How long will a gravity battery last on a burglar alarm if the battery is short-circuited 9 hours per day? (*c*) Is one battery sufficient for a circuit of 300 ft.? (*d*) Is a gravity battery in any way affected by the weather? (*e*) Does it make any difference as to the strength and life of a sal-ammoniac battery whether warm or cold water is used to mix up the solution? W. A. T., Washington, D. C.

ANS.—(*a*) There is a gas igniter that can be carried around to the different gas jets and applied to them in the same way as an ordinary taper. This is the only arrangement we know of that does not require the house to be wired. You can obtain these gas igniters from electrical supply houses, such as the Western Electric Co., Chicago, Ill. (*b*) A good battery should last at least 5 months. (*c*) No; the number of cells required will depend largely on the ease with which the annunciator drops. At least four cells will probably be required. (*d*) Yes; gravity batteries do not work well unless they are kept at a fairly warm temperature, say 60° or 70° F. Their

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internal resistance increases if they become cold. (c) No; warm water might give better results at the time of mixing, but after the cell has cooled it would be no better than if cold water had been used.

***

(120) We have a drilled well 33 ft. deep; water rises to within 15 ft. of the surface; the pipe attached to a pump extends 23 ft. into the well. After 4 or 5 gal. of water have been pumped out at one time, the water becomes brown. When allowed to stand for several hours, the pumped water is clear again. What do you think is the cause?

W. L. S., Fostoria, Ohio.

ANS.—We cannot positively define the cause of the coloring of the water without a personal examination of the well, but it seems evident that the water near the surface is colored with some foreign matter. It may be rust from the suction pipe or from an ironstone vein about that level, or it may be something else. It would appear that when you draw water steadily for a little while that the water-line in the well is lowered and the colored water above descends and is ultimately drawn up the suction pipe and discharged by the pump. When you stop pumping, pure water flows into the bottom of the well and raises the colored water to its original height. This may account for your drawing clear water out first and colored water later on.

***

(121) What is the process of hardening machinery steel, such as is used in universal pipe dies?

J. W. L., Seattle, Wash.

ANS.—As machinery steel can only be case-hardened, it is never used for cutting tools, tool steel being employed for that purpose. Machinery steel can be case-hardened by rubbing it with cyanide of potassium or prussiate of potassium while hot, and then quenching it; or it may be packed in bone dust, powdered charcoal, or leather scrap, in an air-tight box, and kept at a red heat for about 10 hours, and then quenched. Case-hardening will only harden the surface for a depth not exceeding a few thousandths of an inch; hence, case-hardened machinery steel does not answer very well for cutting tools.

***

(122) How many square feet of floor surface is it customary to allow for seating capacity? I want to figure how many people an apartment 45 ft. × 80 ft. will accommodate. W. I. H., Monroe, N. Y.

ANS.—It is customary in churches and similar buildings to allot 2 ft. wide by 2 ft. 6 in., figured from back to back of persons. Where children are to be seated, dimensions somewhat smaller than these are taken. According to this data, your room, which contains 1,350 sq. ft., would seat 270 adults, no allowance being made for stage, platform, or aisles, and, consequently, the space occupied by these would have to be deducted.

***

(123) (a) Does the United States Government issue licenses to stationary engineers similar to those issued by state and municipal authorities? (b) If so, are there different grades, and what are the requirements as to experience, etc.?

J. H. P., Pullman, Wash.

ANS.—(a) Stationary engineers employed in certain branches of the United States Government service must pass an examination under civil-service rules. (b) Full information regarding the different grades and their requirements can be obtained from The Civil Service Commission, Washington, D. C.

***

(124) (a) I have charge of a dry kiln containing about 3,000 ft. of 1" pipe, 150 ft. of 2" mains exposed, and 50 ft. of 1½" mains exposed. The lowest point of the drain pipe is 4 ft. below the water-line of the boiler, and, when improvements now under way are made, the water-line in the boiler will be about 6 ft. above the lowest point of the drain pipe. Can the water condensed in the kiln be returned to the boiler at a distance of 200 ft. by means of a steam loop? (b) Can you give me any data in regard to the dimensions required for the return pipe of such a loop?

E. W. K., Hoquiman, Wash.

ANS.—(a) Yes. (b) We would advise you to consult Westinghouse, Church, Kerr & Co., 26 Cortlandt St., New York City, who have charge of the sale of this device, which is patented.

***

(125) Explain how to calculate the horsepower of a steam turbine of the Parsons type, described in "McClure's Magazine" for July, 1898.

G. B., Ludington, Mich.

ANS.—We do not know what method is used in estimating the power of a steam turbine. The power of a turbine that has been built can be measured by means of a Prony brake.

***

(126) I wish to connect our fire-engine boiler with the boiler of our electric-light plant so as to be able to run the fire-engine in the engine house, if necessary. Connection is to be made by automatic couplings. The water in the electric-light plant boiler is considerable higher than that in the fire-engine boiler. How can I arrange the piping so that the condensed steam will not fill up the boiler of the fire-engine? The two boilers are 75 ft. apart.

A. W. S., Gaylord, Minn.

ANS.—From your question we infer that you wish to run your fire-engine without getting up steam in its boiler. If that is the case, the best way of doing it would be not to turn the steam into the fire-engine boiler at all, but to make connection directly to the steam pipe of the fire-engine, placing a valve between the point of connection and the fire-engine boiler, to prevent steam from entering the boiler.

***

(127) (a) Which is the proper way to apply the nuts in bolting pipe flanges together: should the flat or the rounded side of the nut go against the flange? (b) Is the rounding of the nut a mere finish or is it made so to fit into the bolt holes?

A. A. K., Loraln, Ohio.

ANS.—(a) The flat side. (b) The rounding of the nut was meant for a finish originally. Turning the round side toward the flange is resorted to as a shop kink, when the holes in the flanges are excessively large compared with the diameter of bolt at hand; it furnishes a means for centering the bolt somewhat.

***

(128) (a) What kind of a machine is used for reboring small steam-engine cylinders and crosshead guides by hand? (b) Can you inform me of a book giving drawings and description for doing such work? P. J. A., Lowry, Mass.

ANS.—(a) For want of a better name, the machine may be called a portable boring machine. It consists of a heavy boring bar sliding in two bearings that are adjusted to suit the center line of the cylinder. The boring bar carries a cutter, which may be set out. The bar is rotated by gearing connected to a hand crank, and is fed along the cylinder or guides by suitable means, such as a screw. (b) We do not know of any such book. Perhaps some of our readers may be able to help you out.

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(129) Do you know of any magnetic tool or swab in the market for cleaning out the iron chips from holes drilled in horizontal presses? If not, do you think such a tool could be made? L. L., Barre, Vt.

ANS.—We have never heard of such a tool being in the market, but have seen a number of home-made ones made of steel wire, magnetized after hardening. The writer has often used one that he made for the very purpose mentioned.

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SCIENCE AND INDUSTRY

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THE PROGRESS OF A CENTURY IN THE GAS INDUSTRY

Thos. N. Thomson

A BRIEF HISTORY OF THE GAS INDUSTRY—TROUBLES OF THE PIONEERS—THE MANUFACTURE OF COAL GAS AND PRODUCER GAS—THE VALUE OF GAS STOVES

OF ALL the great discoveries of the century now quickly ebbing away, it is questionable whether any have been of more real value to mankind than that of gas. Before its discovery, the world was dark indeed; for candles, crude lamps, and solid combustibles of various kinds were the chief, if not the only, means of obtaining artificial light. And the lack of a knowledge of gases was a tremendous drawback to the home comforts and industries of our forefathers.

The steady mellow light that illuminates our homes, offices, workshops, and thoroughfares is not the spontaneous outcome of any one man's fertile brain; it is the natural result of a combination of the clever ideas of many ingenious men, and, like the rich man's son, we should be truly thankful that our fathers were born before us.

To fully appreciate the immense revolution in the methods of obtaining artificial illumination and to compare the great luxuries which we now enjoy with the hardships experienced by our ancestors, we cannot do better than to devote a little attention to the primitive modes of securing artificial light. It is not so very many years ago since the pine knot was used in the remote settlements as "the light for courtship, and it suited very well to sit up by."

FIG. 1.—PINE KNOT OF OUR FOREFATHERS

The pine knot is really a natural miniature gas works, which, when heated, gives off gas that burns with a very unsteady, smoky flame. The burning of the gas converts the resin into more gas, and thus the flame is maintained until the resin stored in the knot becomes exhausted, or until the heat from the flame is insufficient to generate more gas. But the pine knot, with its accompanying soot and sparks, is now a thing of the past, even in the most remote settlements, for candles and, later, kerosene-oil lamps have taken its place. The candle was a decided improvement over the pine knot, because it produced a steadier flame, lasted much longer, and did not fill the atmosphere with those nasty flakes of unburnt carbon that used to fall like black snow.

The candle, like the pine knot, is also a miniature gas works, but not of natural growth; it is the creation of man, and is made of tallow, or its substitute, and a cotton wick. If you look closely at a candle when it is burning, you will notice that heat from the flame melts the tallow into the form of a cup, from the center of which the wick stands up like a little pillar,

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its visible base being surrounded by clear, molten tallow about $\frac{1}{16}$ inch deep. This liquid travels up the wick by capillary attraction, and soon becomes vaporized and converted into inflammable gas by the heat of the flame. If the wick were a piece of iron wire, the oil would not travel up, and, of course, there would be no flame. So you see there is science in a candle, and, although it may appear very simple to us in these days of gigantic demonstrations of science, yet, in its gentle, unimposing way it opened up a new era of light to our ancestors.

FIG. 2.—THE CANDLE A MINIATURE GAS WORKS

The candle, however, had, and still has, its nasty little grease-dripping faults, and so many candles were required to produce a reasonable amount of illumination that the people naturally craved something better. Then the oil lamp became quite popular; for, by a little ingenious device known as the *kerosene burner*, the oil can be burned to produce a steady non-smoking flame of remarkably high candlepower. And the oil lamp, like the candle and the pine knot, is also a miniature gas works that produces inflammable gas by the heat of its own flame. But these automatic gas generators do not interest us so much at present as the real gas that is sold to the inhabitants of cities, towns, and villages by the thousand cubic feet. We will therefore return to the subject and try to follow up the manufacture and distribution of gas from the time it was discovered to the present day.

FIG. 3.—THE POPULAR KEROSENE LAMP AN AUTOMATIC GAS GENERATOR

It was about the year 1792, not very long after Dr. Priestly discovered oxygen and Dr. Black produced carbonic-acid gas, that Wm. Murdock, a canny Scotsman who was working as an engineer in Cornwall, England, first entertained the idea of employing gas made from coal to replace candles and lamps. So he made many experiments with different kinds of coal, to determine the best means of depriving the gas of its impurities and burning it. It is recorded in the history of gas engineering that "he had bladders filled with gas, to carry at night, with which, and his little steam carriage running on the road, he used to astonish the people." There is no doubt that Murdock was a man of great ability, but whether or not he had a steam automobile in use more than one hundred years ago, as history records, is hard to say. But we do know, from numerous records, that he did march through the streets with a bladder under his arm and a blazing gas flame held aloft.

Murdock obtained his gas by heating coal in a closed retort, allowing the gas to blow from the retort into the bladder. Any schoolboy that is on good terms with the cook can obtain the same kind of gas if he borrows his father's clay pipe, places some broken *soft coal* in its bowl, closes the mouth of the bowl air-tight with clay, and pushes it into the fire and awaits results. As the coal is heated, the volatile matter is vaporized, while gas and steam mix together and blow out of the stem. The experimenting youth, on placing a lighted match in this stream, instantly ignites the gas and thinks himself great.

FIG. 4.—WM. MURDOCK'S GAS TORCH OF 1792

It is stated that as late as the year 1781, the only means of retaining gases was with bladders or with pneumatic jars, but about that time the noted French chemist, Lavoisier, invented the gas holder, which was substantially the same as those applied to nearly all gas works at present. The first publication of this invention in the English language was made in 1789. It is quite probable that this invention, coming to the notice of Murdock, impressed him with the practicability of lighting houses with gas. But whether this is true or not, the credit for first lighting with gas on a large scale is unquestionably due to that gentleman. Murdock, in 1792, actually lighted his own house and office at Ridruth, England, with gas. He distilled the coal in iron retorts and conveyed the gas through pipes a distance of about 75 feet to his house,

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where he lighted his rooms with the new magic blaze, and filled the bladders for his portable lights.

Murdock's gas works, we can imagine, must have been a great field of study for him, because he was developing an industry that at that time was practically unknown to the world. His pipes clogged, the retorts fouled, and the gas would not burn with a steady flame; it would smoke and sputter, and sometimes go out without any warning, and the light emitted was poor indeed. Notwithstanding these difficulties, he energetically pursued his experiments and tried coal from Newcastle, Swansea, and other places in England and Wales. Then he tried some kinds of Scotch coal, and continued experimenting with coal, wood, peat, and other inflammable substances during his leisure moments, until, finally, he became satisfied of the practicability of successfully lighting houses, villages, towns, and even large cities, with gas generated at a central station. Therefore, he continued experiments on burners, varying in many ways the shape and position of the orifices for the emission of the gas, until at last he obtained a burner that in many ways resembled the Argand burner of the present time. It was simply a ring of small holes,

FIG. 5.—HOW A BOY ON GOOD TERMS WITH THE COOK CAN MAKE GAS

and it gave good results. His attention was then directed to the necessity of removing impurities from the gas, and he certainly adopted the expedient of allowing it to bubble up through water. But it would appear that he knew nothing about the advantages of lime as a purifier, for Dr. Henry and Mr. Clegg discovered this valuable purifier later on.

About the year 1796, Murdock communicated with his friend James Watt, son of James Watt, the celebrated engineer, explaining the apparatus, and stating his idea of employing gas as a substitute for candles and oil lamps, and suggesting that a patent be obtained on the contrivance. But Watt's father, some time before, had spent enormous sums of money in defending steam-engine patents, and young Watt, consequently, did not entertain Murdock's idea with much favor. However, Murdock kept toiling on, and, in the year 1798, he lighted the Soho engine works with gas and gave his friends a free exhibition of gas lighting on a big scale. This act saved him in after years, when he had to prove to the courts priority of invention.

FIG. 6.—MURDOCK'S FAVORITE RING BURNER

In 1799, a French engineer named Lebon obtained a patent in France for "an economical method of employing fuel," and later he obtained a supplement to the patent, in the specifications for which he describes the "method of producing and burning gas; also the means of obtaining motive power therefrom," all of which was substantially the same as Murdock's arrangement, made and in operation seven years before. In 1801, James Watt's brother, while in Paris, foresaw the progress that was about to be made in gas lighting there, and he wrote home saying, "If anything is to be done with Murdock's gas, it must be done at once, as there is a Frenchman in Paris who has similar ideas and proposes to illuminate this city by these means." This put the Britishers on their mettle, and the next year, 1802, saw a public exhibition of gas lighting at the Soho works. A great man of that day, named Mathews, in one of his writings, said: "The illumination of the Soho works on this occasion was of the most extraordinary splendor; the whole of the front of that extensive building was ornamented with a great variety of devices that admirably displayed many of the varied forms of which gaslight is susceptible. This

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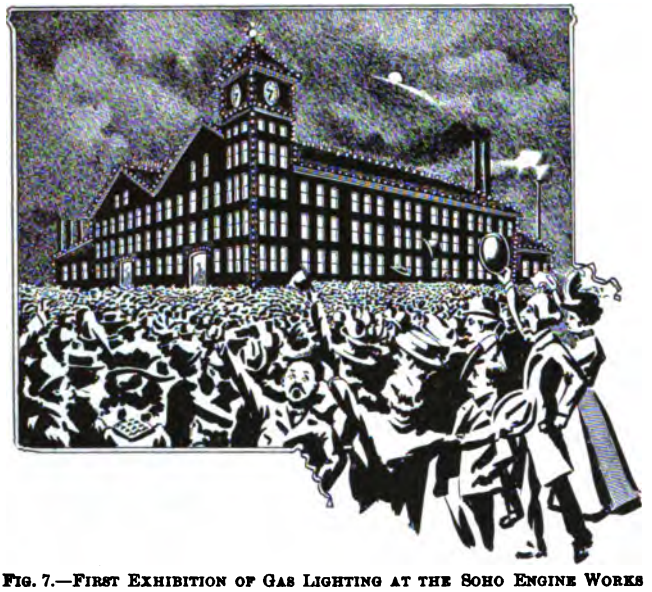

FIG. 7.—FIRST EXHIBITION OF GAS LIGHTING AT THE SOHO ENGINE WORKS

luminous spectacle was as novel as it was astonishing, and all Birmingham poured forth its numerous population to gaze at and admire the wonderful display of the combined effects of science and art."

In 1803, a complete gas works was erected by Murdock on the premises of Messrs. Boulton & Watt; and the following year, 1804, saw the extensive cotton mills of Phillips & Lee, of Manchester, all lighted with coal gas. The results were so satisfactory that, in 1805, Murdock presented a paper to a philosophical society on his method of lighting these mills. He does not mention in detail the process employed for obtaining the gas, but merely states that "the coal is distilled in large iron retorts, and the gas issuing from them is conveyed by iron pipes into gasometers, where it is washed and purified, previous to its being conveyed through other pipes to the mills." In the cotton mills, he supplied 271 of his ring burners, each of which gave a light equal to four 6-to-the-pound candles; the mills were also provided with 633 cockspurs, each of which produced a light 2¼ times as great as one of the 6-to-the-pound candles, which consumed tallow at the rate of 175 grains per hour. In the same paper, Murdock showed that it would require £3,000 per annum to buy enough candles to light the cotton mill 3 hours per day, and that his plant was producing an equal volume of light at the rate of £650 per annum.

Money in those days talked just as loud as it does today, and the mill owners throughout the country soon commenced to install gas plants, while Murdock was awarded Count Rumford's gold medal. Gas engineers and contractors sprang up like mushrooms, and speculators tried to monopolize the gas industry, as well as to deprive poor Murdock of the fruits of his hard labors.

One adventurer in particular, named Winsor, was more daring than all the rest put together. He patented Murdock's ideas, then gave public exhibitions in the theaters of London, and delivered lectures wherever he could, collecting money everywhere to form a gigantic stock company. The scoundrel described himself all over the land as the discoverer, inventor, and patentee of gas lighting, and agitated the necessity of at once forming a company to light the houses, mills, streets, etc. of the entire British possessions, so that all British subjects might enjoy the advantages of his great discoveries. But the public looked upon him with extreme distrust, for he told them such barefaced lies in the name of science that even the uneducated people could "see through him." Yet, strange to say, he raised £20,000 and occupied premises in Pall Mall, where he fitted up gas-manufacturing works and other apparatus in the basement, to illustrate his lectures. Here he demonstrated to the public, free of charge, the practical utility of gas for lighting, heating, and cooking purposes. The journals of that day put forth objections and arguments against gas manufacture in general, and Winsor in particular, being backed, no doubt, by all the candle, oil, and lamp manufacturers in the country. But the self-constituted champion of the new magic light met all

FIG. 8.—COCKSPUR BURNER

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comers with that extraordinary courage, perseverance, and zeal that so strongly characterized him. He was a clever and, in a way, intelligent man, but he lacked the scientific knowledge so essential for the successful accomplishment of his great self-assumed task. In the middle of his eloquent orations, when the audience was becoming deeply absorbed in his scheme, and saw visionary fortunes in store for them if they would but invest a few pounds in gas stock, he would blast their hopes and make them boil with fury by such fabulous statements as, "Yes, gentlemen, the atmosphere in its pure state is altogether too powerful for the human race; it requires to be diluted with a mixture of coal gas to make it more salubrious and more conducive to longevity." All this occurred after noted scientists had clearly demonstrated that coal gas was poisonous to breathe and that nothing could live in it. Wild statements like these retarded the progress of his scheme, and, if he had been less sanguine and a little more like other folks, success would have come quicker and have been better assured.

However, this indomitable individual was determined to spend that 20,000 hard-earned pounds in venture, so he laid a pipe line in Pall Mall to the corner of James Street westward, and to the Haymarket eastward, planting lamp posts at short intervals all along the line, and not forgetting to place a goodly number in front of Carlton House, then the residence of the Prince Regent. On January 28, 1807, one side of the street was lighted with gas, and, on June 4, the King's birthday, both sides were gorgeously illuminated, and remained illuminated during the sessions of Parliament. This was the first public street ever lighted with gas. With the lights blazing in the eyes of the King Regent and the members of Parliament, the invincible Winsor endeavored to obtain an act of incorporation and charter, so that his company might control the entire gas industry of the empire, but the privy council would not grant it. Three times he tried to secure a royal charter, and, in 1812, he got one, but the privileges accorded were not liberal, for the company had no right to prevent other people from competing with them. The first gaslight company being thus legally established, they commenced, like a lot more of their kind at the present day, to place the business in the hands of a number of chemists and other theoretical men to experiment at the expense of the stockholders. The result of such folly then was precisely the same as is experienced now, for the stockholders' money went out swiftly and nothing seemed to come in for a long time. The stockholders, however, discovered this leak before the company ran dry, and effectually stopped it by placing Mr. Clegg, an expert mechanician of the Watt and Murdock types, in supreme control; then the company made money rapidly, and gas lighting became established. This accomplished, and the trade being open to all, there arose rival concerns all over the kingdom that flourished at the expense of the old experimental company.

Such is the history of the establishment of the gas industry in Great Britain. Now let us see what it has done for us on this side of the Atlantic. About the time that Murdock and the others were working to establish the new light in England, a certain David Melville, residing in Newport, R. I., commenced to operate in the same line. He was so successful in his experiments that about 1812 he completed a gas plant that lighted his home and a large portion of a street with gas manufactured by a peculiar process of his own. And a little later he installed a gas plant for the illumination of a cotton mill in Watertown, Mass., then a large mill in Providence, R. I. He was so pleased with the results of these plants that in 1813 he took out a patent for his ingenious apparatus. But the pioneer gas city of the United States is Baltimore, for it was here

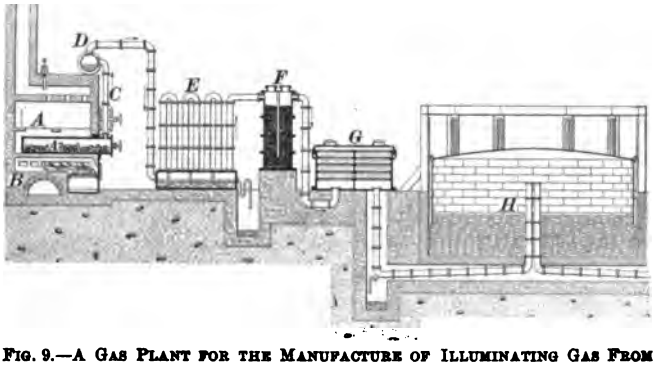

FIG. 9.—A GAS PLANT FOR THE MANUFACTURE OF ILLUMINATING GAS FROM BITUMINOUS COAL

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that, in 1816, the first gas company was regularly organized for the purpose of illuminating American cities with the new light, and today the metropolis of Maryland still holds its own as one of the busy centers of the American gas industry.

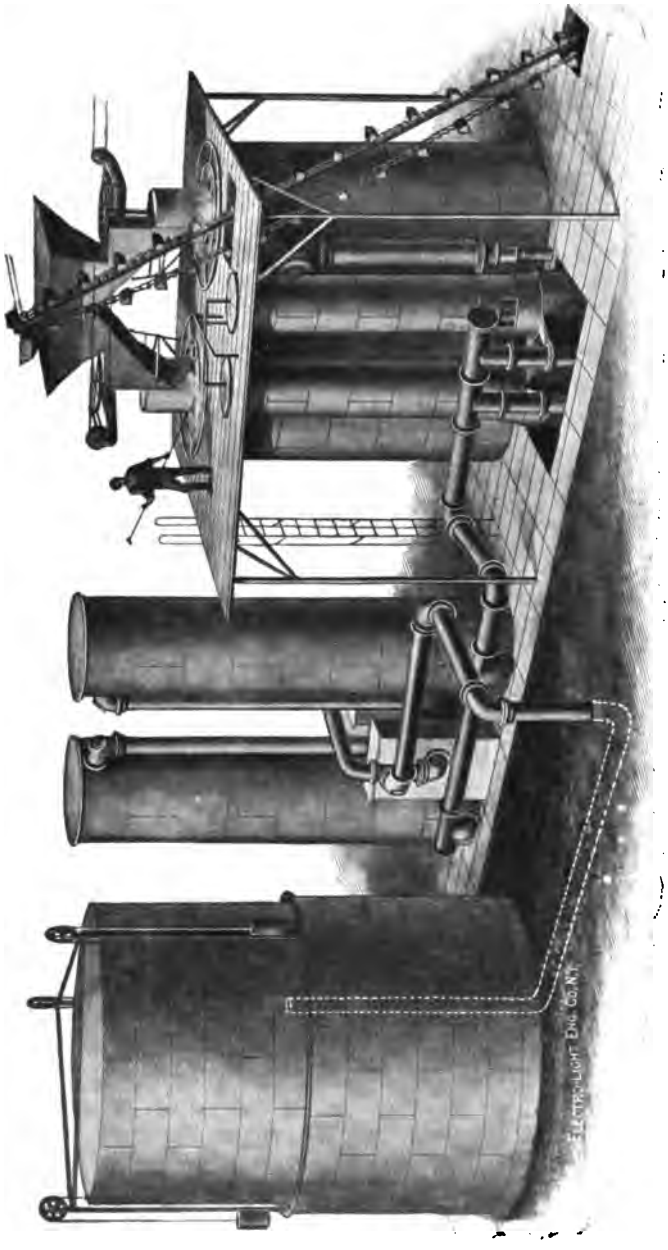

FIG. 10.—A TAYLOR PRODUCER PLANT FOR THE MANUFACTURE OF FUEL GAS FROM ANTHRACITE COAL.

In 1815, the erection of gas works was begun in Philadelphia, but the interested parties must have been at loggerheads with the soft-coal miners of Pennsylvania, for they were determined to make their gas out of wood, and they stuck to the absurd idea so long that the company went under. Eleven whole years expired before the wood-gas notion became sufficiently suffused with the atmosphere of common sense as to admit the presence of a new idea, so that, in the year 1826, some clear-headed individuals, seeing the progress that was being made in the old country and in the larger cities of this country, got together and proposed to start a new concern for the purpose of lighting the City of Brotherly Love with coal gas. But the "brotherly love" was so intense that the new proposition was affectionately crushed to the wall before the organizers had an opportunity to show what they could accomplish. Time rolled on in Philadelphia, as it did elsewhere, until 65 years ago, when some of the readers of this article were boys; then the gas question sprang up in that city like a mushroom. Before the old-time objection party could raise its voice, the younger citizens had pushed an ordinance through the legal channels, and the chief city of Pennsylvania was destined to be lighted with gas from "stem to stern," as the sailors remarked when they saw the city's lights at night. This franchise provided for the incorporation

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of a company with $100,000 capital. The works, being immediately put under way, were completed in 1836. The first year's production was 17,000,000 cubic feet of gas, distributed among 7,000 consumers and to 300 street lamps. Philadelphia has flourished ever since.

While Philadelphia was sleeping, people in Boston, New York, Brooklyn, and other large cities were installing gas works and illuminating houses, offices, and streets. For in 1822, about seven years after the Philadelphia wood-gas scheme exploded, the first gas works of Boston was erected, and, on January 22, 1823, the governor of Massachusetts approved an act to incorporate "The Boston Gaslight Company." The charter of this company fixed the capital stock at $75,000. Under this old charter and its several amendments, gas is still supplied to the city of Boston. After a great deal of financial difficulty and public opposition, the property of the old company was sold in 1824 for a little over $2,000. The supply of gas, after the sale, was discontinued, and it was not until 1827, when a Mr. Robinson, who already had considerable experience with gas lighting in Baltimore, purchased the franchise and property, that gas lighting was again resumed in Boston. The man from Baltimore immediately commenced the erection of a new plant, which was completed in 1828. Then he supplied gas at the rate of $5.00 per 1,000 cubic feet. This marked the beginning of a permanent supply of gas to the capital of Massachusetts. Since then Boston has become exceedingly great, and is presumably the center of the intelligence of America.

In 1823, the same year that the Boston charter was obtained, a company was organized to supply gas in the city of New York. It was capitalized at $750,000, with the privilege of increasing to $1,000,000.

The company built its works in Centre Street, near Hester Street, and made gas there until 1850. It operated on the broad-gauge plan, for it erected twelve large gas holders whose combined capacity was 1,600,000 cubic feet, and charged $10.00 per thousand cubic feet. As consumers multiplied, however, and as the number of street lamps increased, the price of gas gradually came down and down, until, in 1860, it was $2.50 per thousand cubic feet; and lately, after a great deal of fighting one way and another, the price of New York gas was down as low as 40 cents per thousand—but it is up again to where it belongs, i.e., about 70 cents per thousand.

In 1825, Brooklyn, N. Y., and Bristol, R. I., were first lighted with gas, and other large cities followed up like so many sheep, until nearly every city and town in the Union finally became lighted with gas.

From the time of the launching of the old Baltimore company down to the time of the Rebellion, some 300 gas companies had been formed, and they supplied light to over 5,000,000 people. Now, more than 1,000 cities and towns, in the United States alone, are supplied with gas, the invested capital being over $500,000,000, and annual consumption over 70,000,000,000 cubic feet. If this is not a gigantic industry, then what is? And it has presumably accomplished more for civilization than any other new industry of the century.

But let us look into the technical side of the gas business a little, and learn how gas is made, distributed, and consumed. Until recent years, only one kind of gas was used for illuminating and heating purposes, and that was obtained by the distillation of bituminous coal. The demand for gas, however, became so great that new processes were invented, and other varieties of gas have been introduced, so that now there are many different kinds of gas made and marketed for different purposes. The varieties most commonly used are coal gas, oil gas, water gas, producer gas, natural gas, gasoline gas (or carbureted air), and acetylene.

A coal-gas plant is shown in Fig. 9. Bituminous, or soft, coal, occasionally mixed with a little cannel coal, is shoveled into closed earthenware retorts *A* that are located in the combustion chambers of large fires. The heat breaks up the combinations of hydrogen and carbon that exist in the natural coal, and transforms them into other compounds, most of which are gaseous at ordinary temperatures. Among the new compounds thus made are tar, ammonia, and sulphureted hydrogen. The tar condenses in the apparatus and is pumped out. The ammonia is formed by the union of hydrogen with nitrogen, and has an offensive odor. The worst impurity, however, is formed by the union of hydrogen with sulphur contained in the coal. This is called *sulphureted hydrogen*, and is one of the vilest-smelling substances known. As the gas is formed in the retorts, it travels up the pipes *C*, passes through the hydraulic main *D*, where it drops some of its impurities and

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passes through condensers *E*, where the gas is cooled and certain vapors are condensed. Then it flows through a scrubber *F*, where falling water on coke beds still further purifies it. Then it flows through oxide-of-iron or lime purifiers *G*, where it receives its last cleaning before it passes into a gas holder *H*, where it is stored under a constant pressure until drawn off through the street mains by consumers. To prevent gas from backing into the retorts when they are being charged, the outlet of *C* is sealed in the liquid of the hydraulic main. Gas made by this process is especially adapted for illuminating purposes, and the coke, tar, and other products of the distillation are valuable marketable articles.

Petroleum or any variety of animal or vegetable oil, grease, or fat may be used instead of coal. Even city garbage has been used successfully for the production of gas by substantially the same process. Producer gas differs from the coal gas commonly used for lighting purposes in having less combustible matter and a large percentage of nitrogen. The average quality of producer gas contains from 10 to 15 per cent. of hydrogen, and from 20 to 30 per cent. of carbon monoxide. These constitute the combustible part of the gas, nitrogen forming 40 to 60 per cent. of the total volume. This gas burns with a dull reddish flame, and its value for heating purposes is about one-fourth that of an equal volume of good coal gas.

FIG. 11.—A WELSBACH INCANDESCENT GAS BURNER

Producer gas is made by burning coal, either bituminous or anthracite, in a closed furnace with a supply of air that is purposely made too small to permit of perfect combustion. The air is usually supplied by a steam-jet blower, and the amount is regulated so that it is barely sufficient to convert the carbon in the fuel into carbon monoxide. The nitrogen in the air remains unchanged and passes off into the gas pipes with the carbon monoxide as an inert, useless accompaniment, merely swelling the total volume of the product.

Fig. 10 shows a popular gas-manufacturing apparatus, known as the *Taylor producer*. It is composed of two producers connected up together, with a platform on the top, and an endless-chain feeding attachment; this is where the gas is made. A pipe connecting the top of each producer with the base of each scrubber, shown in the middle of the cut, conveys gas from the producers through economizers to the scrubbers, where it rises in each scrubber through a shower of falling water or some other cleansing medium, and is discharged from the top, by the two vertical pipes shown, into the rectangular purifiers near by. Another pipe, part of which is shown by dotted lines, conveys the now purified gas to the gas holder shown at the left of the illustration. Another pipe, not shown here, leads the gas from the gas holder to the points where it is consumed.

Many of the largest engineering works in the United States are not only lighted with gas, but are also supplied with power as well, through the medium of gas engines. It has been found that small sizes of anthracite coal, such as buckwheat or rice, can be used to great advantage as the fuel in this producer. Indeed, gas producers are made that utilize the natural waste or refuse from mining operations, and it may not be many years before the massive mountains of culm that now disfigure the mining regions will be converted into cheap power by gas producers and gas engines, and the now much despised culm piles will be converted into mountains of gold for their owners.

Water gas is a mixture of hydrogen and carbon monoxide, with only a very small percentage of nitrogen. It is made from anthracite coal or coke and steam. The coal, in lumps from 2 to 3 inches in diameter, is placed in an air-tight cylinder lined with firebrick. It is ignited, and blown to a bright incandescent heat by means of an air blast; then the blast is shut off and a current of dry steam is blown through the mass of glowing fuel. The great heat causes the steam to break up into free oxygen and hydrogen. The oxygen combines with the hot carbon, forming carbon monoxide, and

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the hydrogen passes along with it, but without combining. These are then led off through suitable pipes to a gas holder. As soon as the incandescent fuel becomes a little dulled, or cooled, the steam is shut off and the fire is again blown up bright with the air blast. The operations of blowing up and making gas are worked alternately at intervals of about five minutes, until the fuel is exhausted. The fresh gas as thus made contains less carbon than good coal gas, and, consequently, will not burn with as bright a flame. It burns perfectly in heating burners, but, when it is used for lighting purposes, it is always enriched, that is, made richer in carbon. This is done by vaporizing a quantity of petroleum by heat, and injecting it into the hot gas before it leaves the generator containing the injection, until the percentage of carbon in the gas is raised to the desired standard.

FIG. 12.—A WELSBACH TABLE LAMP—A GREAT IMPROVEMENT OVER THE OLD TALLOW CANDLE

After the gas is made, no matter what generators are used, it is stored in gas holders and used when needed. The gas holder allows the gas men to make gas during the day, when but little is used, and the gas holder gives it out to the consumers at night, when there is a heavy demand for it. Thus a large gas holder allows a small gas plant to supply gas to a very large number of people, by working night and day. It is needless to say that the monster cylinder seen at every gas works is a gas holder. It is nothing but a bell, with its sides dipping into a deep water seal. This bell is raised by gas being forced into it. A number of pulley wheels on top of the bell roll on vertical guides and prevent the holder from sticking against the iron network around it. When the holder is at the top of its surrounding network it is full of gas, but when it is empty the bell is nearly or entirely out of sight, and the network bracing looms up against the sky like a monster skeleton.

Not only have great strides been made in the manufacture, purification, storage, and distribution of gas to large communities, so that good gas shall be on tap all the time and at a fairly steady pressure, but ingenious improvements have also been made on the methods of combustion in order that the greatest amount of light or heat may be utilized from the gas. For example, we have the Welsbach burner, a device that gives us over five times as much light for the money expended as the common open-flame burner. This is obtained by simply hanging a fragile mantle made of rare earths over a Bunsen flame. The heat of this flame makes the mantle incandescent, and an intensely bright and steady light is produced. This is one of the most beneficial discoveries of our time, for it practically turns night into day. But progress in furthering the comfort of gas consumers does not stop with the Welsbach light.

One of the latest inventions is a method of dispersing or diffusing the artificial light, or in bending its rays, so to speak, that the

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light can be shed just where you please. This is accomplished by the use of what is known as "Holophane" glass globes. Common globes only protect flames or mantles from drafts, but the Holophane does all that, and at the same time reduces the intensity of the light without affecting its volume to any great extent. The objection to intensely bright and dazzling lights is the injurious effect of the glare on the eyes. The peculiar corrugated construction of these globes softens the light without wasting any more than is wasted by the use of plain, clear globes. But this is not the only benefit derived from these globes, for, by slightly changing the shapes of the prismatic forms of the corrugations, most of the light emitted can be projected upwards, downwards, horizontally, or uniformly diffused, according to the class of globe employed. For the general illumination of a room by chandeliers, the class B globes are most desirable. Everybody that uses common gas fixtures has noticed that most of the light goes up to the ceiling if reflectors are not used to throw it down. But reflectors absorb light also, and people that pay gas bills often feed reflectors.

The question of more light to read and sew by at night has arisen in nearly every home supplied with gas. Indeed, it has demanded such attention that gas-fixture manufacturers do a large business in supplying the demand for portable lamps that may be hooked on to the chandelier with a rubber-tube connection, while the lamp burns brightly on the table like the Welsbach portable shown in Fig. 12. If the proper kind of a Holophane glass globe is used on the chandelier, the expense and inconvenience of portable lights is avoided, because a large volume of light can be thrown down by the class A Holophane globe. This light is very mellow, and seldom, if ever, injures the eyes, for its source is overhead and thus outside of the general vision. For economy, comfort, and general utility, gas is, and probably ever will be, the popular light for the home.

As an artificial light for streets and thoroughfares, gas is superior in nearly every respect to electricity, because the light is not so intense in some places and so lacking in others. The shadows produced by electric lighting are very deep, while those from gas are barely perceptible. In electric street lighting, by arc lamps, the lights are necessarily so far apart and of such intensity that pedestrians must shade their eyes with their hands as they pass from the utter darkness of the shadowed places to those lighted by the dazzling rays of the hissing, unsteady, nerve-shaking arc lamps. It is altogether different with gaslight in the streets, for the lamp posts are so close together and so low down that few shadows exist, other than the narrow lines from tree trunks or telegraph poles. Even these are softened by a judicious distribution of the gaslights.

One of the most beautiful illustrations of street illumination was presented at the great National Export Exposition at Philadelphia last year. Welsbach lamps in chandelier form, fitted with shades and cups such as shown on the reading lamp, Fig. 12, were suspended in the north and south pavilions. The illumination from these was sublime. The mantles were not visible at all, and the pavilions were simply flooded with a soft mellow light that would soothe the nerves of the most irascible spectator. A large number of the booths were provided with Holophane globes, so that spectators might see the exhibits without being compelled to wink their eyes all the time or use smoked glasses.

On both sides of the esplanade were arranged rows of single-light lamp posts, while along the middle a row of three-light posts were arranged, as shown in Fig. 13. Thus, the esplanade was lighted as brightly as at noonday, and remained so every night of the exposition, without even the faintest indication of a distinct shadow. This is known as almost perfect artificial illumination. When Holophane globes, class C, are used for street lighting, the result is magnificent, for the most of the light is thrown outwards to the space between the lamps, and a nearly equal illumination can be secured all along the street. How different this is from the present harsh and cruel methods of lighting by electric arc lamps. The gas lighting of the Exposition at Philadelphia gave a heavenly tone even to the fakirs at the gates.

The use of gas in the household is not confined to lighting, for a large quantity is now consumed for cooking purposes. Indeed, cooking by gas has become so popular, and is so general with intelligent women in both America and Europe, that some of the largest manufacturers in the world are now producing enormous outputs of gas cooking apparatus. As a labor-saving device, and as an economizer in the kitchen, but few of the nineteenth-century inventions can be compared to the gas stove. It is a

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godsend to the noble women that cook our meals during the hot summer weather. The American kitchen is truly a great field for the gas-stove business, because these places are intolerably hot during summer if coal fires are run in the cook stoves, and the poor women that swelter in them are often the wives of American men that are only too willing to reduce the labors and increase the comforts of their "better halves" when they have the opportunity. To such men that have gas pipes in their kitchens, I would say, "Get a good gas stove at once and you will never regret it. Do not imagine for a moment that it costs a little fortune to run a gas stove. It does not. It is much cheaper than using coal during summer; this is a fact that has been proved time and time again." Of course, it is true that a wasteful servant will run up enormous gas bills, but it is likewise true that the good woman who shares your joys and sorrows has a great deal of respect for your pocketbook and will not allow the gas to burn when it is not in use. Cooking with a gas stove is a simple science that comes naturally to women, for they can regulate the heat to the occasion. But cooking with a coal or wood stove is guesswork, for the heat is seldom "twice the same." It is the gas stove that has made life endurable in city flats during summer, and it is the gas stove that will increase the comforts in many a country kitchen as well. Fig. 14, which shows how easily cooking is accomplished on the "Jewel" gas stove, should convince any fair-minded individual of this fact.

We cannot expect a great deal from gas in the way of heating buildings in America, because of the long bitter-cold months we so often experience during winter, and because of the high price of gas. But gas heaters are particularly inviting when in the form of open fires, for we all like to sit around a blaze when the weather is cold. And they are particularly valuable for temporarily heating parlors and other small rooms in buildings that are huddled together in blocks, for each keeps the other warm.

FIG. 13.*—A BEAUTIFUL ILLUSTRATION OF STREET LIGHTING IN PHILADELPHIA LAST YEAR

Gas as a power in the world of machinery has grown extensively within the last ten years, and gas engines are rapidly displacing steam engines. Indeed, it is a known fact that power developed by gas engines is cheaper than that developed by steam engines, and many engineers at the present day are embarking in the gas-engine industry because it is so plainly seen that the best days of the steam engine are gone. Some years ago, Professor Kennedy, an undisputed authority, stated that "a steam engine cannot possibly convert into work more than 30 per cent. of the heat energy put into an engine, while a gas engine may attain at

* We are indebted to the "Progressive Age" for this illustration.

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FIG. 14.—THE AMERICAN GAS STOVE—A LABOR-SAVING DEVICE AND AN ECONOMIZER IN THE KITCHEN

least 80 per cent. efficiency." In America, Great Britain, Germany, and France gas engines have displaced steam engines to such an amazing extent that steam engineers are shaking in their shoes lest they be compelled to swap the old boiler for a gas producer, and learn how to regulate the puff of a gas engine instead of setting the valve of a Corliss. When we consider the immense amount of nature's wealth that is blown up toward heaven through steam-engine exhaust pipes, and wasted, and compare this waste with the almost perfect utilization of energy by the gas engine, and at the same time think of the many other superior merits of the gas engine, we may pardon any individual for prophesying that, before the coming century is ended, the great steam-engineering industry of the world will either have one foot in its grave or be dead altogether. This appears to be the trend of the times. A good gas engine can run night and day, week in and week out, if necessary, and almost without attention. There is no noise, no odor, no overheating of engine room, no dirt, no muss of any kind, and it takes up so very little space that gas engines bid fair to become popular in all coming large buildings. Electric light generated by gas engines is cheaper than gaslight itself, so you can see the force of converting gas energy into electric power by gas engines.

The commercial field for the gas-engine business is too extensive to be properly described. We will only state that if gas engines are worked in connection with electric generators, they can be applied to many useful and labor-saving purposes. They will not only produce safe and brilliant means of illumination for buildings, streets, and grounds, but power can be applied to elevator service, ventilating fans, pumps, laundry work, sewing machines, lathes, and other things. Gas engines can also be used to supply storage batteries in yachts and automobiles. Heating can also be applied electrically for cooking and warming the house. Indeed, the possible utilities are so numerous with an established gas engine and electric plant, that it would be a waste of space and time for us to try to enumerate them.

The manufacture and utilization of acetylene gas, which is made from the exceedingly bountiful supplies of coal, lime, and water, is opening up a new branch of the gas industry that bids fair to revolutionize the artificial

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illumination of the world. This new gas, when consumed at proper burners, can produce a light of 240 candlepower when burned at the rate of 5 cubic feet per hour. This consumption is equal to that of an ordinary open-flame gas burner, and we can conceive the advantages of acetylene when we consider that the open-flame gas burner only gives about 16 candlepower.

We would like to say more about acetylene and its prospects, but we feel that we have taken up enough of your valuable time already, and, therefore, will postpone this subject till some future occasion.

SERIES ARC LIGHTING WITH ALTERNATING CURRENT

R. B. Williamson, M. E.

ADVANTAGES OF SERIES ARC LIGHTING — CONSTANT-CURRENT TRANSFORMER — OPERATION OF CONSTANT-CURRENT TRANSFORMER—SERIES ENCLOSED ARC LAMP

ALTHOUGH alternating current has now been used for at least twelve or fifteen years for incandescent lighting, its use in connection with the operation of arc lamps has been very limited until recently. Systems for operating arc lights by alternating current have been brought out from time to time, but have never been able to compete with the old-established direct-current systems. This was no doubt due in a large degree to the fact that alternating-current arc lamps as previously made were unsatisfactory. They were not economical, and were very noisy in their operation. A good healthy alternating-current arc lamp of the old type could make its voice heard even when hung up on a pole outdoors; and for interior illumination the noise was so pronounced as to be a great drawback to the use of this current. Moreover, these lamps did not give a very good distribution of light for general illuminating purposes, as they threw the light upward to a much greater extent than the direct-current arc.

FIG. 1

With the introduction of the enclosed arc it was found that an alternating arc lamp could be made to work in a satisfactory manner. In this type of lamp, which is now so well known as to need scarcely any description, the arc is surrounded by a small glass globe. The heat of the arc expels the greater part of the air from this globe, and, since the burning takes place in a partial vacuum, the carbons last much longer and the lamp can be operated with a long arc. The light produced is peculiarly soft and steady, and is well distributed for general illuminating purposes. These lamps take a smaller current than the ordinary arc lamps, and require a correspondingly higher voltage on account of the increased length of the arc. These enclosed arc lamps have been used most largely up to the present time on constant-potential circuits, but they have also been run in series on direct-current circuits.

It was soon realized by station managers that for street lighting it would be desirable to have a system of operating these lamps in series, because the constant-potential, or parallel, system of distribution is not well adapted for lights scattered over wide areas, on account of the expenditure necessary for copper. Moreover, the tendency of all modern central stations is to do the greatest variety of work possible with the least number of different types of machine. The operation of incandescent lamps from alternating-current

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FIG. 2

stations requires the use of the ordinary constant-potential alternator. On the other hand, the series arc system requires a constant current; and if a transformer is used that can transform from constant potential to constant current, the ordinary arc dynamos may be replaced by these transformers and the station equipment greatly simplified.

Having given a few of the points showing the desirability of such a system, we will describe the apparatus brought out by The General Electric Company for this purpose. This plan of lighting was first used in Hartford, Conn., and has since been successfully installed in a number of places. Fig. 2 shows a street provided with these lamps. With the exception, perhaps, of the reflector, there is very little to distinguish them from ordinary arc lamps, so far as general appearance goes.

The chief feature of the system is the special transformer for changing from constant potential to constant current. This is the invention of Prof. Elihu Thomson, and it forms a most interesting piece of apparatus. The device was patented some years ago, but has only now been brought out in practical shape. Fig. 4 shows the general outside appearance of the transformer as built in the larger sizes, and Fig. 6 shows the mechanism. Fig. 5 shows the arrangement of the essential parts of one of the smaller sizes. It consists of a laminated-iron core of the double-circuit type, built up in much the same way as an ordinary transformer core. The primary coil PP surrounds the middle limb, and is fixed in the position shown. The secondary coil is of the same shape as the primary, and is arranged so that it can move freely up and down. This secondary coil is connected to the arc-lamp circuit, and the primary coil is connected to the primary mains from the alternator. When all the lamps are burning, i. e., when the E. M. F. in the secondary is at its highest value, the secondary coil rests directly on the primary in the position $S'S'$. When the lamps are all cut out, the secondary is practically short-circuited, and the coil occupies the position SS. The movable coil is suspended from quadrants on the end of a lever, and is partially counterbalanced by weights. When all the lights are in operation and the current is at its normal amount, the weights are adjusted so that the secondary rests on the primary. The current in the primary coil tends to set up magnetism through the core, as shown by the dotted lines. The magnetism set up by the secondary is, however, opposed to that in the primary, and the tendency is to set up magnetic leakage between the coils. This can be seen to better advantage when the coil occupies the mid-position $S'S'$, where the lines of force leaking across are shown by the full lines. The current in the secondary coil flows in a direction directly opposite to that in the primary. It is a well-known fact that,

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when two conductors are placed side by side and carry currents flowing in opposite directions, they will repel each other, and hence in this case there is always a repulsive effect between the coils. Now suppose that, when the two coils are together, a number of lights are turned out; the current will at once tend to increase, and hence the repulsive effect will be so increased that the secondary will move up until the balance is again restored by the current coming back to its normal amount. This means that the secondary voltage decreases as the coils move apart, because the farther they are apart, the greater the number of lines that will leak between them. The number of lines of force that pass through the secondary will, therefore, be decreased, and the secondary voltage be correspondingly diminished.

In the large transformer shown in Fig. 6 there are two fixed primary coils with two secondaries free to move up and down between them. These two movable coils are counterbalanced against each other, and the weight required to counterbalance the repulsion is carried on a small auxiliary lever. These transformers maintain a remarkably constant current throughout their range of action. By using the adjustable quadrant shown in Fig. 6 the effective length of the lever arm may be made to vary with different positions of the coil, and the transformers can be adjusted to give a larger current at full load than at no load if desired. The current for which they are generally adjusted is 6.6 amperes. Fig. 4 shows the transformer mounted in its corrugated cast-iron case, the regulating lever with its counterweight being also shown. The whole transformer is immersed in oil, which not only serves to secure good insulation but also conducts the heat to the outer case, and at the same time prevents sudden movements of the coils by making the whole arrangement act as a dashpot. These transformers may be installed in the power station itself or at any convenient substation where they can be supplied with current from the constant-potential primary mains.

FIG. 3

FIG. 4

Fig. 1 shows one of the enclosed lamps, with its reflector. The power required for each lamp is about 425 actual watts, of which 25 watts are used in the lamp mechanism. With the normal current of 6.6 amperes, about 72 volts are required at the arc. Fig. 3 shows the lamp with the

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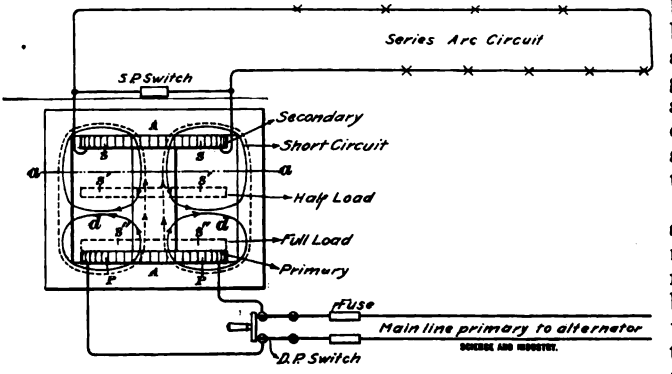
outer globe off and the case removed. The small globe enclosing the arc is shown, as well as the main parts of the mechanism. The lamp works on the differential principle. The two magnets shown are placed one above the other, and pull in opposite directions on a laminated armature. When the arc become long, enough current passes through the lower magnet, which is in shunt with the arc, to pull down the armature and cause the lamp to feed. The lamp is provided with a cut-out, so that the circuit will not be broken in case of an open circuit in the lamp or an accident to the carbons. A coiled spring is used to take up the vibrations of the armature and thus prevent humming. These arc lamps require a very good grade of carbon, but the increased cost is more than compensated for by the length of time the lamps will burn before they need retrimming. The cost for carbons for each trimming is about 2½ cents, and the lamps need trimming, on an average, about once a week. All lamps of the enclosed type should be carefully trimmed, because if care is not taken, the result may be that too much air will get into the globes when the lamp is burning. In fact, it has been found best to have a duplicate set of inner globes that can be cleaned and provided with lower carbons at the station and then used to replace the globes on the line.



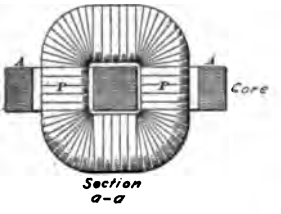


FIG. 5

Taken altogether, this system forms one of the most interesting improvements that has been brought out in connection with arc lighting for some time. The transformers require little or no attention; certainly they are much less expensive and troublesome than the average arc machine. The illuminating power of the lamps seems to be quite satisfactory, the light being very soft and steady, without the glare so noticeable in connection with ordinary arc lamps. It is an excellent system for plants equipped with alternators, as it enables the arc lamps to be operated satisfactorily by putting in a special transformer instead of a direct-current arc machine.

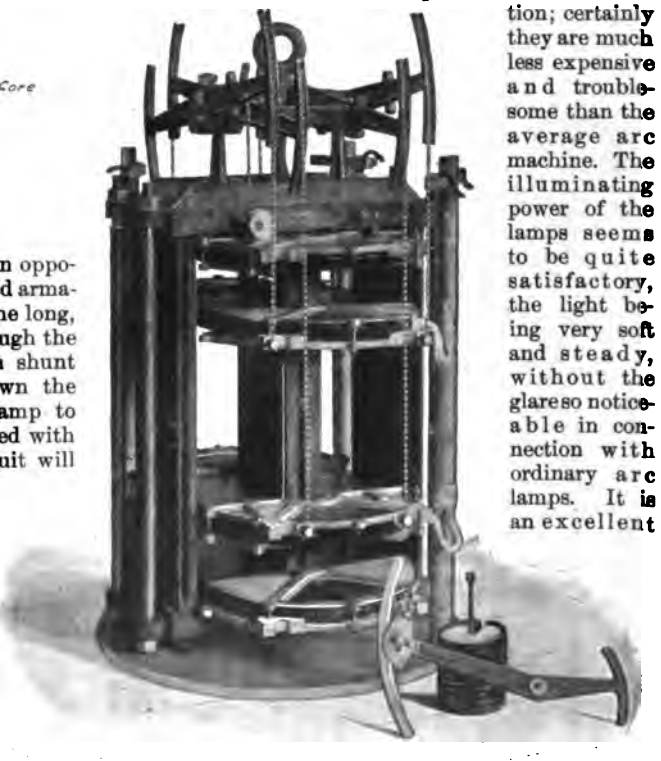


FIG. 6

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THE BRACING OF STEAM BOILERS

John A. Grening

SURFACES IN NEED OF BRACING—METHODS OF BRACING—LOAD ON BRACES—CALCULATING THE SIZE OF STAYS AND BRACES—DIAGONAL STAYS—RIVETS

THE surfaces of steam-boiler shells are, in general, either cylindrical, hemispherical, or flat. A cylinder or a sphere subjected to an internal pressure is *self-supporting;* that is, the pressure tends to maintain the cylindrical or spherical form of the vessel, and hinders distortion instead of producing it. If the vessel is composed of flat surfaces, however, an internal pressure tends to distort it and give it an approximately spherical form. Then, as flat surfaces are not self-supporting, it follows that they must be stayed or braced.

The flat surfaces commonly found in stationary boilers are the boiler heads of the ordinary return-tubular boiler, and the heads, flat sides, and tops of fireboxes of internally fired boilers of the locomotive type. The heads of stationary boilers are supported in various ways. Probably the most common method is to support them by crowfoot braces, which are securely riveted to the head and the shell. The crowfoot brace is shown in Fig. 1 (*a*). In this style of brace, the crowfoot is formed by welding flat bars to a cylindrical stem. The strap end, or part that is riveted to the shell, is also welded to the stem. An improved form of crowfoot brace is the McGregor brace shown in Fig. 1 (*b*). This brace is formed by a piece of sheet steel, bent in one heat, as shown. Being weldless, it may naturally be assumed, and the assumption has been borne out by experiments, that, for equal cross-sectional areas, it will bear a much greater strain than the welded crowfoot brace. It will be observed that the crowfoot of the McGregor brace is formed by splitting the sheet and bending it at a right angle. In the Huston improved crowfoot brace, shown in Fig. 1 (*c*), the crowfoot is formed by flanging the plate itself, thus giving probably the strongest form of crowfoot that can be devised.

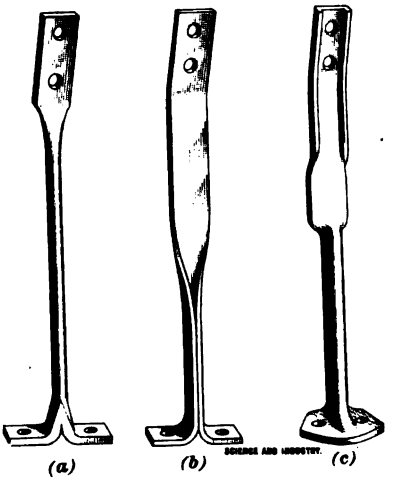

FIG. 1

Small boilers carrying a rather low steam pressure occasionally have the heads braced by angle irons or T irons riveted to the head. For higher steam pressures, the angle irons or T irons may in turn be supported by braces, one end of which is riveted to the shell and the other end either forked to straddle the leg of the T iron or flattened to go between two angle irons. Connection between the angle iron or T iron and the brace is then made by a cotter, and, in better work, by a bolt and nut. Channel irons riveted to the inside of the head, and in turn supported by stayrods, have also been employed for high-pressure boilers. For large boilers carrying high pressure, the most direct way of supporting the heads is to employ through stayrods spaced about 14 inches from center to center. These, in the best construction, are rods passing through both heads, and provided with nuts on both sides of the heads. A large washer on the outside, or a reenforcing leaf, is riveted to the head, which reduces the bulging under pressure and allows the stayrods to be widely spaced.

Numerous modifications of the methods of bracing here given are to be met with in practice. For staying the flat surfaces of the water legs of boilers of the locomotive type the usual and most direct method is to employ screw staybolts, which are screwed both into the inside and outside sheets, and then riveted over at both ends while cold. Staybolts for these surfaces being subjected to a great deal of alternating bending stress (in addition to a direct tensile stress) will sooner or later break off close to the sheets. In order to give warning of this, in good work, holes are drilled axially in the center

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of each staybolt, and extend at least ½ inch beyond the internal surface of the sheets. Should a bolt break, the steam or water issuing from the hole will give warning of the break. In boilers coming under

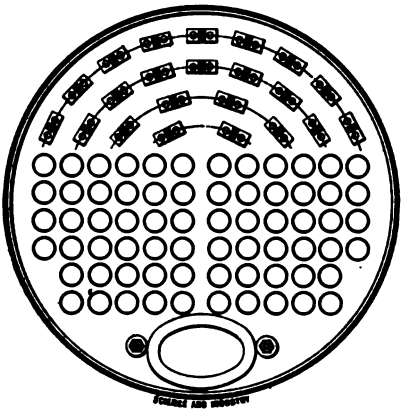

FIG. 2

the supervision of the United States Steam-Vessel Inspection Service, screw staybolts are not allowed to be used any more unless they are drilled at each end. Instead of riveting over the ends of the staybolts, they may be fitted with a nut. This is the usual practice in Scotch marine boilers; it is rarely done, however, in stationary work.

For supporting the crown sheets of internally fired boilers of the locomotive type, many methods are in use. Probably the most common method is to stay the crown sheet by staybolts screwed and riveted to the sheet, and suspended from girder stays extending across the sheet. The girder stays in turn are tied by flat bars to angle- or T-iron rings riveted to the inside of the shell. When the crown sheet is cylindrical, or approximately so, it is often supported by long stays screwed and riveted both into the shell and into the crown sheet.

In staying boilers, it should be the aim of the designer to distribute the stays as equably as possible over the area to be braced. The process of laying out the bracing is a tentative one, involving the use of judgment and common sense. After the number of braces of a given size has been determined by calculation, it will frequently be found that with the chosen number of braces an equable distribution is out of the question. Then a different number of braces, and, perhaps, even a different size of brace, will have to be chosen.

The arrangement of braces depends, to a large extent, on the shape of the area to be braced. For rectangular areas, such as are presented by the firebox sheets of boilers of the locomotive type, the most common and natural method is to arrange the stays in equidistant horizontal and vertical rows. For bracing the heads of return-tubular boilers, the Hartford Steam-Boiler Inspection and Insurance Company advocates arranging the braces in concentric rows, as shown in Fig. 2, the design shown being for a 72-inch boiler braced by crowfoot braces riveted to the head and shell. When the head is stiffened by T irons, an excellent arrangement of them is that shown in Fig. 3. As will be observed, the T irons are arranged radially, and each is securely riveted to the shell. The forked end of the braces is then cottered to the T iron between the rivets, as shown. The great advantage of this system of bracing is that by it the number of braces is reduced, thus making the boiler more accessible for cleaning and repairing. The reduction in the number of braces naturally requires each brace to be larger.

When angle irons are used, a common plan is to arrange them as shown in Fig. 4, and rivet them securely to the head. The braces supporting the angle irons are then distributed as shown. The area supported by each stay or brace is the area bounded by lines midway between the stay and the nearest stays surrounding it. Thus, in Fig. 5, the dotted lines show the area supported by the central stay. When stays

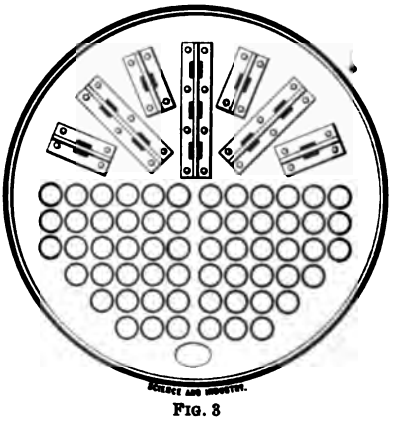

FIG. 3

are arranged in equidistant rows, as shown in the figure, which is the usual way of arranging them in the flat surfaces of fire-box boilers, the area supported is equal to the square of the center-to-center distance, or *pitch*, of the stays.

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In calculating the total area that is to be supported, it can safely be assumed, for a boiler head, that the flanging of the head will support it for a distance equal to six times the thickness of the plate. Likewise,

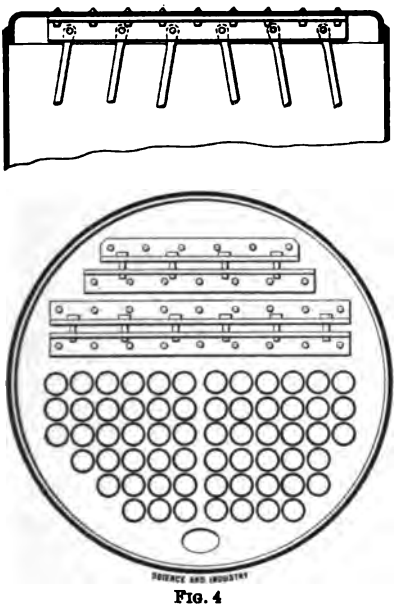

FIG. 4

with the flat surfaces of the firebox, the flanging of the end sheets will support them to a distance that may be taken equal to six times the thickness of the plate. In the case of the head of a horizontal return-tubular boiler, the tubes, when well rolled, act as stays and render further staying of this part of the boiler unnecessary. The tubes may also be assumed to safely support the head for a distance equal to about one and one-quarter times the diameter of the tube, measuring from the center of the upper row of tubes. Thus, in Fig. 6, with a boiler head $\frac{1}{2}$ inch thick, and tubes $3\frac{1}{2}$ inches in diameter, the areas to be supported by staying are those enclosed by dotted lines. The flange of the head supports it for $\frac{1}{2} \times 6 = 3$ inches; the tubes support the head for a distance of $3\frac{1}{2} \times 1\frac{1}{4} = 4\frac{3}{8}$ inches from the center of the tubes. The total area to be supported can now be calculated by the rules of mensuration, taking the necessary measurements from a scale drawing. The total pressure, or load, on the area to be supported is the product of the steam pressure and the area in square inches.

Considering the thickness of the plate to be braced, it is evidently necessary to have the braces or stays close enough to each other to prevent excessive bulging between the stays. In other words, the area that each stay or brace supports should not exceed a certain number of square inches; the area depending on the thickness of the plate and the steam pressure to be carried. This area has been determined experimentally, and is given by the following rule, which has been deduced from rules of the Board of Supervising Inspectors of Steam Vessels:

RULE I.—*Multiply 112 by the square of the thickness of the plate in sixteenths of an inch, and divide the product by the steam pressure in pounds per square inch. The quotient will be the maximum area, in square inches, that can be supported safely by one stay. For plates above $\frac{7}{16}$ of an inch in thickness use 120 instead of 112.*

From this rule, the maximum pitch of stays, arranged in equidistant rows, can readily be found by extracting the square root of the area given by rule I.

While the rule is only prescribed by law for fireboxes, furnaces, and back connections of marine boilers, it may advantageously be applied to the heads and other flat surfaces of stationary boilers as a test of the spacing of the braces and stays. For example, suppose it has been decided to use 8 stays on the upper part of the 60-inch boiler head shown in Fig. 6. Let the area be 720 square inches. Then, with the stays equably distributed, each stay will support $720 \div 8 = 90$ square inches. Suppose the head is $\frac{7}{16}$ of an inch thick, and the steam pressure is to be 100 pounds. Then, by rule I, the maximum area is $\frac{112 \times 7^2}{100} = 54.88$ square inches. This shows that there are not enough braces for the given steam pressure and thickness of boiler head. Hence, if the steam pressure cannot be lowered or the thickness of the head increased, the number of braces must be increased. Knowing the area allowable for each stay and the total area to be supported, the minimum number of stays is evidently the total area divided by the area allowable for each stay. Thus, taking the same example as above, there should be not

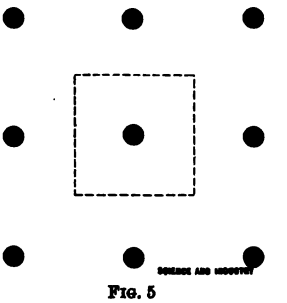

FIG. 5

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less than 720 ÷ 54.88 = 13+, say 14, braces. When plotting the distribution of braces over irregular surfaces it will often be found that, with the number of braces calculated as above, an equable distribution is impossible. In that case use the next larger number that will insure a good distribution. For

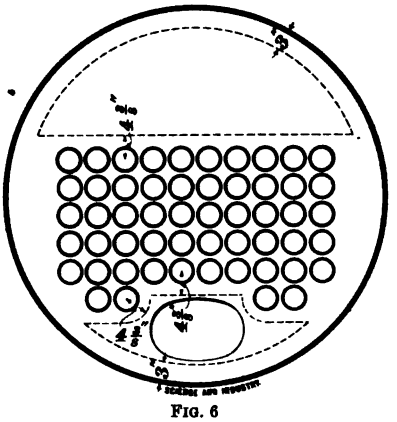

FIG. 6

instance, in a design of head-bracing for a 60-inch boiler head to carry 100 pounds pressure, designed and advocated by the Hartford Steam-Boiler Inspection and Insurance Company, we find 15 braces used, against 14 found by calculation.

Having determined the number of braces or stays, the next step is to find the load each stay has to support. This load, in case of direct stays (stays at a right angle to the surface), is equal to the product of the area supported and the steam pressure. Thus, for stays in equidistant rows and with a 6-inch pitch, for a steam pressure of 100 pounds, the load on each stay will be $6^2 \times 100 = 3{,}600$ pounds.

In the case of crowfoot and other stays making an angle with the surface supported, the load on each stay will be increased by reason of this angle. The load on such a stay can be found by the following rule:

RULE II.—*Divide the length of the center line of the stay, measured between the points of intersection of this center line with the head and shell, by the perpendicular distance between the intersection of the center line of the stay with the shell and the head. Multiply the quotient thus obtained by the product of the area and the steam pressure.*

For example, take the crowfoot stay shown in Fig. 7. Let the area supported be 60 square inches, and the steam pressure 100 pounds. Then, by rule II, the load on the stay is $\frac{4.5}{4.0} \times 60 \times 100 = 6{,}750$ pounds. With stays making an angle with the surface they are to support, the load on each stay should be calculated, as the different stays make different angles with the surface. Having determined the load on the stays or braces, the minimum area of the stays or braces that is sufficient to safely bear this load must be found. In all boilers constructed for marine work, the greatest load per square inch of section of the brace is fixed by law at 6,000 pounds. In stationary boilers, it is usual to allow a load as high as 7,500 pounds per square inch of section. Then, to find the minimum area of the brace or stay, that is, the area at the smallest part, expressed in square inches, we have the following rule:

RULE III.—*Divide the load on the stay by the allowable load per square inch of section.*

For example, take a crowfoot stay on which the load is 7,000 pounds. Then, allowing a load of 7,500 pounds per square inch, its minimum area must be 7,000 ÷ 7,500 = .933 square inch. If the stay is round, the diameter corresponding to this area is $1\frac{1}{8}$ inches, nearly.

The rules previously given will allow us to solve all problems relating to the staying of boilers by direct and diagonal stays, with the exception of the riveting of the feet and shank of crowfoot braces, for which rules will be given further on. We will now show some applications of the rules, taking some regular examination questions for examples.

EXAMPLE 1.—How many $\frac{7}{8}$-inch staybolts are required for a crown sheet of a locomotive boiler to carry 120 pounds steam pressure? The sheet is 5 ft. × 6 ft. Allow a load of 6,000 pounds per square inch of section on the stay.

SOLUTION.—In this example, the thickness of the plate is not given, hence the number

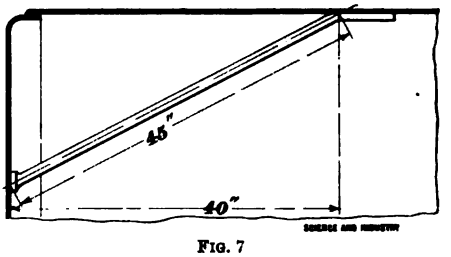

FIG. 7

of staybolts cannot be calculated from rule I. But, since the size of the staybolts is known, the load each staybolt can bear can be readily calculated, and, by dividing the total

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load by the load on each staybolt, the number of staybolts can be obtained. The area of the sheet, in square inches, is $4 \times 12 \times 6 \times 12 = 3{,}456$ square inches. The total load is $3{,}456 \times 120 = 414{,}720$ pounds. The area of a $\frac{1}{2}$-inch staybolt, assuming that the bolt is $\frac{1}{2}$ inch at the bottom of the thread, is $(\frac{1}{2})^2 \times .7854 = .601$ square inch, and the load it can bear is $.601 \times 6{,}000 = 3{,}606$ pounds. Then, $414{,}720 \div 3{,}606 = 115$ staybolts.

EXAMPLE 2.—There are 48 staybolts in a sheet 40 in. $\times$ 50 in. What size should they be for a steam pressure of 100 pounds? The total load on the sheet is $40 \times 50 \times 100 = 200{,}000$ pounds.

SOLUTION.—Since there are to be 48 staybolts, the load each staybolt will bear when equably distributed is $200{,}000 \div 48 = 4{,}167$ pounds, nearly. Allowing a load of 6,000 pounds per square inch of section, the minimum area, by rule III, will be $4{,}167 \div 6{,}000 = .6945$ square inch. The diameter corresponding to this is $\sqrt{\frac{.6945}{.7854}} = 1\frac{1}{16}$ inch, nearly.

Since the thickness of the plate is not mentioned in the two examples just given, it is impossible to say whether or not there will be excessive bulging of the plate between the stays when the pressure is applied. The questions given are actual examination questions that have been asked candidates for a stationary engineer's license. The answers given, and the method of working the problems, while usually satisfactory to the examiner, are scarcely satisfactory to a designer. For an actual design it is recommended that these calculations be checked by considering the thickness of the plate and applying rule I, thus preventing an excessive center-to-center distance of the stays.

We will now take up the riveting of crowfoot and similar braces to the head and shell. Evidently, the rivets should be just as strong as the brace. Unfortunately, the rivets securing the crowfoot to the head are not in direct tension, and cannot be calculated for a straight pull, as can be done for the brace itself. Generally speaking, it has been found that if the combined sectional area of the two rivets in the crowfoot is made equal to one and a quarter times the minimum area of the brace, they will be as strong as the brace. Thus, for a crowfoot brace $1\frac{1}{4}$ inches in diameter, the area of which is $(1\frac{1}{4})^2 \times .7854 = 1.227$ square inches, the combined area of the rivets should be $1.227 \times 1.25 = 1.524$ inches, whence the area of each rivet is $1.524 \div 2 = .762$ square inch. The corresponding diameter is $\sqrt{\frac{.762}{.7854}}$ = say, 1 inch.

A great many boilermakers make the area of each rivet equal to one-half the area of the brace, but, as this will leave the rivets weaker than the brace, it is better to make them larger.

The rivets securing the shank of crowfoot and similar braces are in single shear, and may be calculated from the shearing strength of the material. In practice, however, it is the usual custom to make their combined area equal to one and a quarter times the area of the stay. The rivets securing T and angle irons to heads are in direct tension, and may be calculated for tension, taking a low value of safe tensile strength. In general, it will not be advisable to allow a greater load than 4,000 ponnds per square inch of section on the rivet. Rivets smaller than $\frac{3}{4}$ inch should never be used.

Having laid out the rivet centers on the drawing board, spacing them as equably as feasible, the combined cross-sectional area of all the rivets can readily be found. Thus, if the area to be supported is 720 square inches, and the pressure 100 pounds, the total load is $720 \times 100 = 72{,}000$ pounds. If there are 31 rivets, as in Fig. 4, each rivet must bear a load of $72{,}000 \div 31 = 2{,}323$ pounds, nearly. Then, the area of each rivet is $2{,}323 \div 4{,}000 = .58$ square inch. The corresponding diameter is $\sqrt{\frac{.58}{.7854}}$ = say, $\frac{7}{8}$ inch.

In laying out the rivet centers it is not always possible to distribute them evenly over the surface to be braced. A case in point is shown in Fig. 3. As will be observed, the rivets have been arranged in groups of two, and these groups are distributed as evenly as possible. In such a case it is well to calculate the rivet size for the assembly of groups having the least number of rivets for the largest number of stays. Thus, in Fig. 3, the vertical T iron in the center carries 3 stays with 8 rivets. Plot on the drawing board the area supported by the 3 stays; calculate it, and then multiply by the steam pressure to get the total load on the 8 rivets. From this, obtain the diameter of the rivet in the way previously explained. It is the usual practice to use the same size of rivets for all head-bracing; hence, the rivets that carry a smaller load would be mad equal to those carrying a larger load.

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LIVE LOADS IN BUILDINGS

S. S. Constable

USUALLY ASSUMED TOO HIGH—WHY SMALLER LOADS SHOULD BE TAKEN

IT HAS too long been the practice of the architect and engineer, in assuming the live loads in buildings, to consult precedent and lose sight of the actual conditions. There is no doubt that in doing so they are on the side of safety, but what an extremely costly side it sometimes is for their clients. We little know, and realize less, what a vast amount of unemployed capital there is stowed away in good material, occupying valuable space, and doing no work other than that of holding up its own weight. Especially should economy in design be practiced today, when material is at a premium, and the price of wood, iron, and steel keep climbing up the scale, slowly, to be sure, but still climbing, until before we realize it the cost of building has increased one-third at least.

There is no doubt of the difficulty that the problem of ascertaining the actual live load required in the proposed building offers to solution; and yet, when we consider that the increase of the live load by 10 pounds, in one of our sky-scraping offices, means an additional cost of many thousand dollars, it behooves us, if we would be honest with our client, to carefully analyze the requirements of the building, and at least approach the truth in our assumptions.

The dwelling house with its floor loads need not be especially considered, as engineering skill is seldom necessary in its design, and, besides, certain practical considerations must be fulfilled; so that the floors in the modern dwelling are usually many times stronger than are actually required, though it must be remembered that on some occasions the dwelling house is subjected to as great live loads as halls of public assembly. Besides, it is not unusual that the once stately city house finds itself in queer company; the tallow factory across the way, and the adjacent grocery warehouses with their ever-clinging aroma of coffee and molasses, are not pleasant neighbors, and so the occupants resign the house to the commercial world, and it is cruelly compelled to sustain great loads of filled flour and sugar barrels—so different from the gay burdens of bygone days—until the very joists sag with weariness, and have to be propped with coarse hemlock, a veritable forest of uncouth roughness. To guard against such a condition of affairs would be to anticipate the future, a practice that, though well enough at times, cannot be recommended. Altogether, the practice of assuming the live load of 70 pounds per square foot of floor surface in city dwellings and a corresponding load of 40 pounds per square foot in country houses, does well enough and probably cannot be improved.

The live load in office buildings and places of public assembly, such as churches, theaters, and halls, is altogether a different matter. Here the live loads should be a determinate factor, or at least approximately so, and should be assumed only after due deliberation. It has been the custom in the design of these buildings to figure on the weight of a dense crowd of people. Such a basis of calculation would be logical enough if the true weight of an average crowd of people were assumed, and the fact considered that much of the floor space in such buildings is occupied with light furniture fixed to the floor, which absolutely precludes the possibility of such a crowd. Unfortunately, however, from an economical point of view, many practicing architects take the weight of a crowd of people at 150 pounds per square foot of floor surface. This figure is undoubtedly due to the results of a test made some time previously, in which 58 stout and brawny laborers were packed on a space of 57 square feet; their combined weight being found to average 147 pounds per unit of area.

The absurdity of applying such data to every-day building is evident; when by repeated counting the number of people in the crowded aisles and standing rooms of theaters has failed ever to reveal a weight of more than 40 or 50 pounds per square foot of floor surface. Bearing in mind, also, that the fixed theater seats or church pews—which, in the least commodious quarters, occupy, with their clear space in front, a floor area of 5 square feet—cannot accommodate more than one person; and, assuming the weight of the seat to be 20 pounds and that of the occupant to be 150 pounds, which is an excessive average, the combined weight is only 170 pounds, which, being distributed over 5 square feet, averages only 36 pounds per unit of area.

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True, such a thing as an alarm of fire may cause a panic in which the crush of the crowd might become so great as to increase the weight on the floors to double the usual load; even then, 150 pounds per foot of area would hardly be realized; and, moreover, if such a thing did happen, it is very probable that it would be locally confined, and could not be distributed over any considerable area. In fact, if every seat in the theater were occupied, and the standing room and aisles crowded to their utmost, it would be impossible for the people in the seats to get into the aisles with sufficient rapidity to create a material increase above the normal load at these places. And, even if all the people in the seats where the pro rata is 5 square feet were to crowd over the backs of the seats into one-fifth of the space they formerly occupied, the live load would hardly reach 150 pounds. Such an improbable occurrence would not happen more than once in the lifetime of a theater, and the usual large factor of safety allowed for such buildings would be amply sufficient for such a contingency, even though 80 pounds per square foot had been originally assumed as the probable live load.

Would it not be well, then, in the design of such buildings, provided the ordinances of the city or town permit, to adopt a live load of from 70 to 90 pounds, which could be done with perfect safety and considerable saving in cost? It is, of course, for the architect or engineer to propose, and for the owner to approve, which he will not be tardy in doing when he sees the possibility of saving several thousand dollars.

The most reliable data regarding the live loads in offices show that the weight per square foot imposed on the floor area is astonishingly low in this class of buildings. Some years ago Messrs. Blackall and Everett made a thorough investigation of 210 offices in Boston, with the result that the load was found to be less than 17 pounds per unit of area, while the average of the 10 heaviest offices was 33 pounds, and the maximum live load in any one office was 40 pounds. The buildings were gone over very carefully and the full detail of the contents of the offices obtained, average weights being assumed for the various articles entering into the live loads. The weights of various articles of furniture were averaged from the actual weights of the various pieces. The weights of the safes were taken at the actual figures of the manufacturers. The average weights are given in the following table:

Loads.	Weight. Pounds.
Persons	150
Books, per running foot of shelf	20
Roll-top desks	250
Flat-top desks	125
Tables	75
Chairs	15
Radiators, per running foot	100
Letter presses, including case	100
Toilet wardrobes	150
Folding screens	10
Typewriter	25
Glazed partitions, per running foot	75
Sofas	50
Chests, per foot in length	15
Telephone stands	25
Counters, per foot	50
Open rail, per foot	3
Steel-box safes	2,500

From this data, which there is every reason to suppose represents the usual weights in high buildings of the office type, it would seem that 40 or 50 pounds was a sufficient live load to assume in proportioning the floorbeams, which, of course, must be designed to sustain maximum loads, while 35 or 40 pounds is ample in calculating girders; and it would seem reasonable to design the columns to sustain the full live load on, say, the two floors above, and the average load of from 20 to 25, or even 17, pounds for the rest of the superimposed tiers. The assumption of such loads would be safe beyond question, for the probability of more than two floors being fully loaded is very remote, as it would be practically impossible for people to crowd in any great mass on any number of floors in a modern office building. It will be some years before such small live loads will be assumed in general practice, as at present the building ordinances of nearly all large cities require that the buildings shall be so designed as to sustain ridiculously large live loads that can never be realized.

With warehouses, conditions are materially different. Here, there is no telling what load the floors will be required to sustain. It is not unusual for a warehouse, proportioned to carry light storage, to be leased, in a few years, by a publishing house, who pile it up to the ceiling with bales of calendered paper and bound books, creating loads that the designer never figured on. This is the one class of buildings in which it would seem justifiable to look somewhat into the future, and proportion the beams, girders, and columns for the greatest possible load that might occur.

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HIGH-FREQUENCY TRANSFORMERS ON LOW-FREQUENCY CIRCUITS

WHEN alternating-current plants were first installed, a frequency of 125 or 133 cycles per second was commonly used, and was found quite satisfactory. At that time alternating-current motors had not been perfected, and the current was used wholly for lighting purposes. When alternating-current motors were introduced, it was found desirable to use lower frequencies, since the losses in the motors were greater with the high frequency, and what was even more objectionable, the inductive effects on the line were large. Rotary transformers also operated much better on circuits having lower frequency.

In order to have a frequency that would be fairly well suited for both lighting and power work, the manufacturing companies have adopted a standard frequency of 60. This is not low enough to cause any flickering in the lights, and it operates motors satisfactorily. In a great many cases these 60-cycle machines have been placed in plants that have already been operating 125-cycle transformers, and the question naturally arises: May these transformers be operated on 60 cycles, or must they be replaced by others designed especially for 60 cycles?

Whether or not the high-frequency transformers will operate well will depend largely on the design of the transformer, and in order to examine the effects produced when it is operated in this way we will consider the fundamental relations existing between the primary voltage, primary turns, magnetic flux, and frequency. This relation may be expressed as follows:

$$\text{Primary voltage} = k \times \text{flux} \times \text{primary turns} \times \text{frequency}.$$

k is a constant, the value of which is not necessary for the present purpose. For a given transformer the value of the primary voltage and the primary turns are fixed, because in changing the transformer over from 125 cycles to 60 cycles, it is, of course, assumed that the primary voltage is not altered. We may then write this equation:

$$\text{Magnetic flux in core} = \frac{\text{primary voltage}}{k \times \text{primary turns} \times \text{frequency}}.$$

It will at once be seen from this that if we cut the frequency from 125 down to 60, the magnetic flux in the core must be a little more than doubled in order that the primary coil may generate an E. M. F. equal and opposite to that of the mains. The cross-section of the core is fixed, and in order to double the total flux the density in the iron must be doubled. Now, this means that the primary current at no load, or, in other words, the magnetizing current, must be at least doubled, if not considerably more than doubled, and if the wire in the primary coil is not of ample cross-section, this is liable to increase the heating effect when the transformer is loaded. The loss in the iron core will also be greater on account of the higher density to which the magnetism is forced, but this increase may not be very great because the increased density is offset to a large extent by the decreased frequency.

To sum up the above, it may be stated that, under ordinary circumstances, a transformer designed for operation on a 125-cycle circuit will tend to run hot when operated on a 60-cycle circuit. If the density in the core of the transformer is very low (as it usually is) when designed for 125 cycles, and if the primary wire is of ample cross-section, the heating on 60 cycles may not be sufficient to interfere with the operation. In fact, transformers are now designed that will operate almost equally well on either frequency, but many of the older types were not so carefully designed, and they heated so much on the lower frequency that they could not be used. Of course, the ratio of transformation is not changed in any way, so that although a high-frequency transformer might heat excessively on the low-frequency circuit, it would operate equally well so far as giving the correct secondary voltage is concerned.

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MEASURING SMOKE

D. Petri-Palmedo

SMOKE—SMOKE PREVENTION—THE SMOKE-DENSITY INDICATOR—RINGELMANN'S SMOKE SCALE—SMOKE DIAGRAMS

THE smoke issuing from the many chimneys in a manufacturing town is not only a great nuisance, but represents considerable loss as well, for smoke is finely divided carbon, carried along with the gases of combustion, and, when deposited, is called *soot*, or *lampblack*. This carbon, instead of having been burned to carbonic-acid gas, as it should have been, was heated to incandescence, and then, on account of the lack of oxygen, allowed to cool below the temperature of ignition, which rendered it incombustible. The carbon in the smoke being incombustible, there is no such thing as *smoke consumption*, or *smoke burning*, and there can be *smoke prevention* only by contriving so that the particles of carbon, while incandescent, are brought into contact with the necessary oxygen to form carbonic-acid gas.

There have been suggestions innumerable for the prevention of smoke, in the way of more or less expensive furnace constructions and special appliances for the regulation of the air supply, many of which have certainly proved very meritorious, among them being the down-draft system and various mechanical stokers. In the majority of cases, however, the proper regulation of the air supply will depend on the fireman, and it is safe to say that the best smoke consumer is a good, intelligent fireman, receiving fair wages for reasonable working hours. Nevertheless, with all the care that a fireman may bestow on the fire, the furnace may not attain the highest possible degree of efficiency; for, while he may succeed, with a good furnace, in preventing smoke by properly arranging the fire and the draft, there may be such a thing as *too much* air in the combustion chamber, especially at the time the coal is all incandescent; that is, just before a new charge, which would cut down the efficiency. There is no means for telling by the appearance of the fire alone whether there is too much air or not, and a contrivance designed to supply this means ought to be highly appreciated.

Such a contrivance has lately been brought out by a German firm under the name of a *smoke-density indicator*, and we understand that it is now regularly manufactured. The apparatus is based on the idea that, if the fireman could be enabled to watch the smoke that passes from his furnace, he would endeavor to so grade his fire that the smoke would always show a very light-gray color, next to no color at all, which would indicate

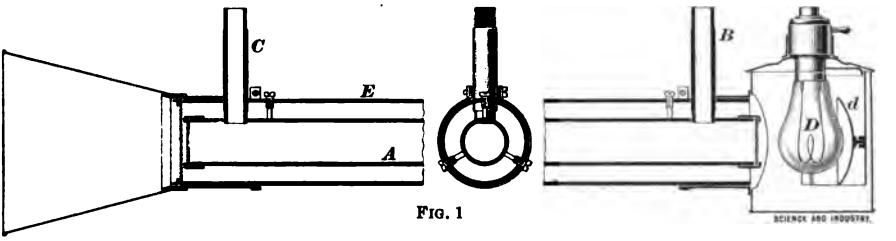

FIG. 1

that the combustion was complete, and that there was not too much air at the end of the gasification period. Of course, the fireman cannot keep running outside to look at the chimney top, so matters must be so arranged that the smoke can be seen from a point near at hand. This the inventors of the indicator have accomplished by inserting into the furnace, where it connects with the chimney duct, a perforated tube that projects out of the setting at some convenient point to connect with the indicator. The latter, according to the *Zeitschrift der Dampfkessel Untersuchungs und Versicherungs Gesellschaft, Wien*, consists of a tube *A*, Fig. 1, about 3 feet long and 1½ to 2 inches wide, closed at both ends by glass disks, and provided with a smoke inlet *B* connected to the perforated tube in the furnace, and a smoke outlet *C* either connected to the chimney or to a small fan, as is most convenient. Smoke of the quality existing in the furnace is thus constantly being drawn through this tube *A*. By placing a light *D* (either an incandescent

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or a kerosene lamp) at one end of the tube, and observing it by looking in at the other end, the density of the smoke can be estimated by the effect it has on the brilliancy of the light. The apparatus, which, thus far described, presents itself in its simplest form, is placed near the water gauge or some other fixture that the fireman is obliged to use frequently, so that he is reminded of its presence. To make the observation easier and more independent of the prevailing conditions of light in the fireroom, the inventors provided another tube *E*, concentric with the first, through which the light *D* shines, also. The front end of this tube is covered by a ground-glass disk. A reflector *d* throws the light forward and projects a dark inner circle on the ground glass (the darker, the denser the smoke is) within a bright outer ring. A funnel serves to make the shadowgraph more marked by keeping off the surrounding light of the room. In this form, the apparatus ought to give good service. For testing purposes, the

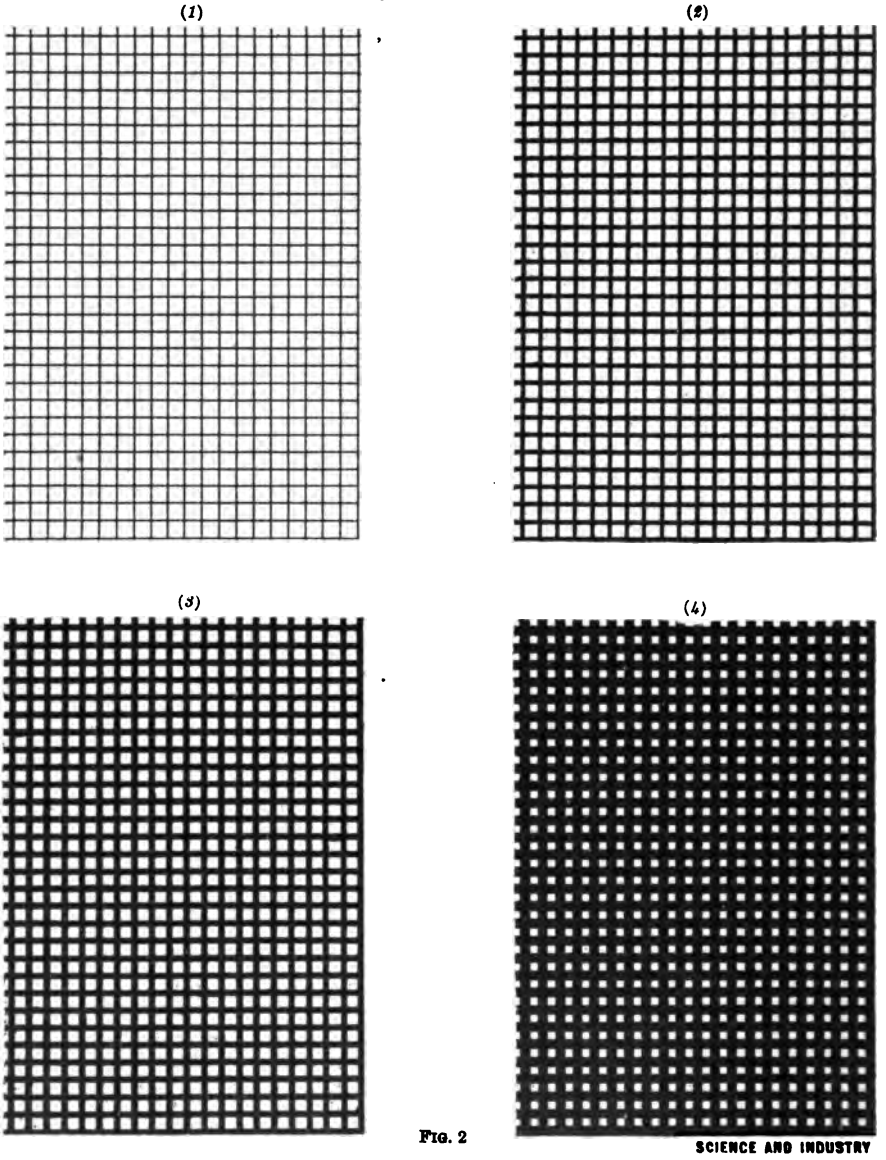

FIG. 2

SCIENCE AND INDUSTRY

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determination of the relative smoke-preventing qualities of various furnace constructions, or the relative smoke-producing qualities of various kinds of coals, or the influence on smoke production and prevention of various methods of firing, the inventors have brought their indicator into connection with a system of smoke measuring proposed about two years ago (*Revue Technique*, 1898) by Prof. Max Ringelmann, of the *Inst. Nat. Agronomique*. We shall describe the system in brief, from which its applicability to the apparatus will be understood.

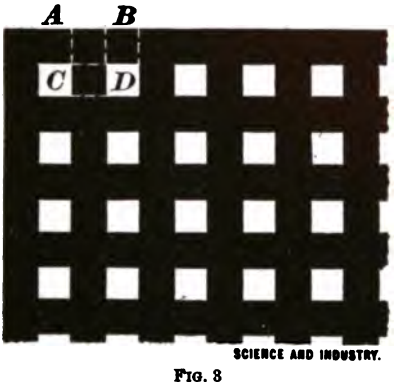

FIG. 3

The system is an improvement on an older method, which consisted in comparing by eye the color of the smoke with a scale of predetermined colors, each bearing a certain number. The trouble with this method was the difficulty of always producing the same tint for each color number. This trouble Professor Ringelmann has overcome by covering sheets of white paper with gratings of black lines, drawn with India ink (Fig. 2). Viewed from a certain distance, dependent on the scale to which the grating is drawn, the sheets look uniformly tinted—the darker, the thicker the lines of which the grating is formed—the distance between the centers of two adjoining lines being the same in all cases.

Such color sheets, instead of being made by the laborious process of drawing lines by hand, can, of course, be produced in quantities much cheaper and much more accurately by photolithography, the gratings being drawn to a comparatively large scale and then reduced in the usual way. The size of the sheets is said to make some difference in the ready distinction of the tints, and is recommended to be not smaller than 4 inches square.

The gratings may be looked on as consisting of a number of squares *A*, *B*, *C*, *D*, Fig. 3.

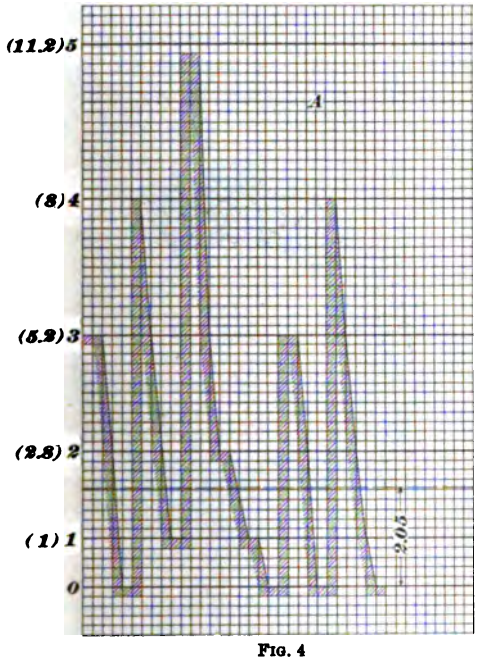

FIG. 4

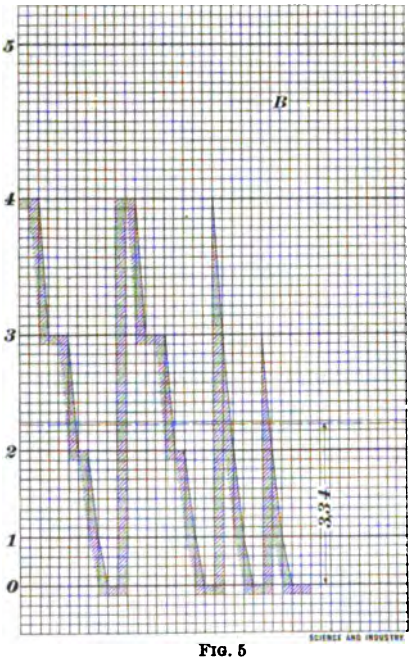

FIG. 5

In order that the observer may not have to stand too far away from the sheets to have the impression from them of a uniform tint, Professor Ringelmann recommends

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that the sides of the squares *A*, *B*, *C*, *D*, be made equal to 2.5 mm. = $\frac{1}{10}$ inch, nearly; then, the area of the square will be $\frac{1}{100}$ square inch. If these squares contain no black at all—that is, when the sheet is white—then it represents

no smoke. (*0*)

When the squares *A*, *B*, *C*, *D* contain 1 part

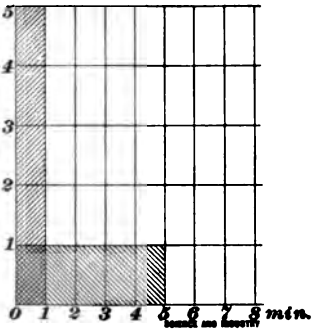

FIG. 6

of black and 4 parts of white, the sheet represents

thin smoke. (*1*)

With 2 parts black and 3 parts white, it means

smoke of moderate density. (*2*)

With 3 parts black and 2 parts white, the sheet resembles the color of

dense smoke. (*3*)

With 4 parts black and 1 part white, the color resembles that of

very dense smoke. (*4*)

An all-black sheet represents

opaque smoke. (*5*)

The portion of the area left white is for the different numbers, respectively:

(*1*) (*2*) (*3*) (*4*)

$\frac{4}{5}$ $\frac{3}{5}$ $\frac{2}{5}$ $\frac{1}{5}$ or

$\frac{80}{10000}$ $\frac{60}{10000}$ $\frac{40}{10000}$ $\frac{20}{10000}$ square inch;

from which the sides of the white squares

$.01\sqrt{80}$ $.01\sqrt{60}$ $.01\sqrt{40}$ $.01\sqrt{20}$, or

.089 .077 .063 .045;

and, consequently, the thickness of the black lines,

.1 — .089 .1 — .077 .1 — .063 .1 — .045, or

.011 .023 .037 .055

(*1*) (*2*) (*3*) (*4*)

The use of the smoke scale is as follows: The observer takes a stand so that the sun will be behind him, and compares the color of the smoke at a height above the top of the chimney equal to the diameter of the chimney. The wind has much to do with the ease of observation, and a windy day is therefore not suitable for the test. The results of such observations are plotted on a sheet of cross-section paper, the horizontal divisions of which represent the time, and the vertical ones the smoke-scale numbers. Diagrams are thus obtained, as shown in Figs. 4 and 5, the areas of which are measures of the smoke-producing quality of the furnace to which the chimney belongs, or measures of the *nuisance* of the smoke, as Professor Ringelmann puts it, or measures of the smoke-producing quality of the fuel employed, or finally of the relative merits of various modes of firing. It will be noticed that the vertical distances between the lines *0*, *1*, *2*, *3*, *4*, and *5* are not equal. There is this good reason for it: If they were made equal, that is, the ordinates proportional to the numbers of the scale, as in Fig. 6, this would indicate, for this figure, that the smoke of the density *5* issuing from a chimney during 1 minute is no greater a nuisance than smoke of a density *1* issuing during a period of 5 minutes. This is not the case, however. The smoke nuisance is directly proportional to the number of suspended carbon particles carried with the gases of combustion. If, now, N is the number of such particles necessarily contained on a unit surface to give it a certain color, or tint, then the unit volume of the smoke contains $(\sqrt{N})^3 = N^{\frac{3}{2}}$ particles. The ordinates representing the smoke scale in our diagram, therefore, must not be

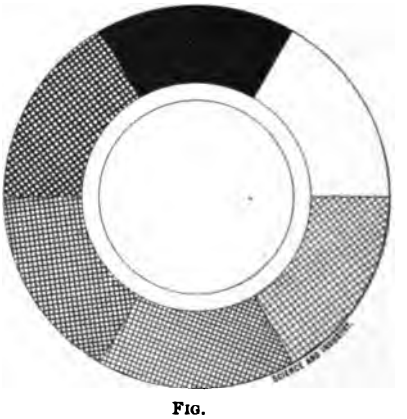

FIG.

directly proportional to the numbers of the scale, but to the power $\frac{3}{2}$ of the numbers.

Thus, we have for the scale numbers

(*0*) (*1*) (*2*) (*3*) (*4*) (*5*),

the ordinates

0 *1* *2.8* *5.2* *8.0* *11.2*.

Such a diagram can be treated exactly

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like a steam-engine diagram, finding, by means of calculation or the planimeter, the mean smoke-density line for the time covered by the test; and, comparing the same with the mean-density line of other tests covering a like period of time, relative data can be obtained. Thus, if Fig. 4 represents the smoking performance of a furnace fired by fireman A, and Fig. 5 that of the same furnace fired by fireman B during equal periods of time, with the same fuel, and all other conditions the same, then we find that the performance of the furnace under A's care is to the performance under B's care as 205 : 334, as far as smoke production is concerned, and as 334 : 205, as far as smoke prevention is concerned.

Referring to the apparatus above described, the same use is made of Ringelmann's scales by dividing the ring-shaped surface of the ground glass between the inner and outer tubes with six sectors, each being covered with a different one of the six gratings, as shown in Fig. 7. It is thus easy, in looking into the tube, to at once tell the density of the smoke by the similarity in shade of the inner circle with one of the sectors of the outer ring. The scheme has, we understand, been carried still further by arranging the ground-glass disk with the scales thereon so that it can be turned around the inner tube. A diaphragm, or partition, is placed behind it in the ring-shaped space between the inner and outer tubes, which partition has one sextant cut out of it. The light shines on the ground glass only through this sextant of the outer tube. By turning the ground glass, that particular sector of it can be brought to register with the sector cut out of the partition, which makes the inner circle and the sector look alike. The motion imparted to the ground glass can finally be transferred to an automatic registering device.

DEATH OF A PIONEER AERONAUT

THE recent death of Mr. H. T. Coxwell, at the age of 81, removes one of the most distinguished pioneers of aeronautics. In the year 1862, a committee of the British Association made a series of unsuccessful balloon experiments for the purpose of making meteorological observations. The failure of these attempts induced Mr. Coxwell to construct a special balloon that was 80 feet high, 55 feet in diameter, and held 93,000 cubic feet of gas. In the ascents, Mr. Coxwell had control of the balloon, and James Glaisher, F. R. S., accompanied him to make the meteorological observations. The first ascent was made on July 17, 1862; on this occasion they attained a height of four miles, and traveled sixty miles in two hours. On September 5, 1862, Mr. Glaisher and Mr. Coxwell reached a height of seven miles, and very nearly lost their lives. At this great altitude men and other mammals experience great difficulty in breathing, and no mammal could endure a much greater elevation, though some birds soar to even greater altitudes.

These intrepid investigators made many ascents together, and made highly important discoveries in meteorology; they discovered that the cirrus clouds that float at great altitudes are composed of ice crystals, and they also found that the direction of the wind changes at different heights. From these and other balloon ascents, valuable information has been gained as to the alternation of cold strata and warm strata of air, the temperature not decreasing regularly as the altitude increases. The ice clouds, which were discovered by balloonists, are much higher than any of the mountain observatories, and therefore cannot be directly observed except by use of a balloon. However, the halo that occasionally surrounds the sun or moon reveals to us the presence of these ice crystals; for the halo is caused by the refraction of the light of the sun or of the moon in passing through the ice needles.

Mr. Coxwell was always strenuous and persistent in maintaining that ballooning should not be regarded as a mere exciting sport, but might be made of great practical utility, both in meteorological observations, and as a means of communication, especially in time of war.

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CENTRAL-ENERGY TELEPHONE SYSTEM

H. S. Webb, M. S.

ONE BATTERY FOR TWO OR MORE TELEPHONES—LINE SIGNALS AND RINGING APPARATUS AT EXCHANGE AND AT SUBSCRIBERS' STATIONS

THE central-energy or common-battery telephone systems are attracting considerable attention at the present time, and it may be interesting to know what kind of apparatus is used and how it is arranged. A central-energy system is generally understood to mean one in which all the batteries and generators, not only those for ringing up the subscriber, but also those for calling up the exchange operator and for supplying current for the subscribers' transmitters, are located at the exchange.

At the first introduction of the telephone, the use of the induction coil in connection with a microphone transmitter was unknown. But it came into use very shortly afterward, and for years no one thought it practicable to use any other arrangement than the one in which the microphone transmitter, a battery, and the low-resistance primary of an induction coil constituted a local circuit, separate from the line and receiver circuit. The comparatively high-resistance secondary of the induction coil, the receiver, and the line formed a separate circuit. The system in which a common battery, two microphones, and two receivers are connected in one simple series circuit without repeating or induction coils of any kind is not practical, except possibly for two telephone sets on an exceedingly short and low-resistance circuit. Neither would such an arrangement be efficient, because the changes in resistance in the transmitter would be a very small quantity compared to the total resistance of the circuit. Moreover, it is also desirable to make one common battery supply current for all the subscribers' telephones. Even if located at the central office, a separate battery for each two subscribers that were talking together through the exchange would be very inconvenient and troublesome, to say nothing of the cost of so many cells.

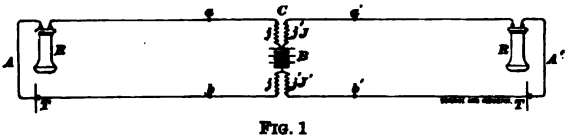

FIG. 1

For a long time, telephone engineers seemed to think that an induction coil could not be used in a common-battery system, or at least they did not know how to use it in such a system. Quite recently, however, by the proper arrangement and modification of the induction coil, the common-battery system has proved quite successful, both for large and small exchange systems, but it has not yet been adapted for out-of-town or long-distance lines.

The principles on which one common-battery system depends will be explained without giving, in the present article at least, the actual switching devices that are used at the central telephone exchange. The common-battery system devised by H. V. Hayes is shown in Fig. 1. The common-battery systems of the Bell companies are operated on this method. In this figure, two subscribers' stations A, A' are shown connected together through the apparatus at the central exchange C, where the common battery B is located. T, T represent the transmitters, and R, R the receivers. Two repeating coils J, J' are employed at the central exchange. These repeating coils are merely induction coils having two coils of equal resistance and the same number of turns. They are wound upon a soft-iron wire core, so arranged as to form a closed magnetic circuit, and in practice the four

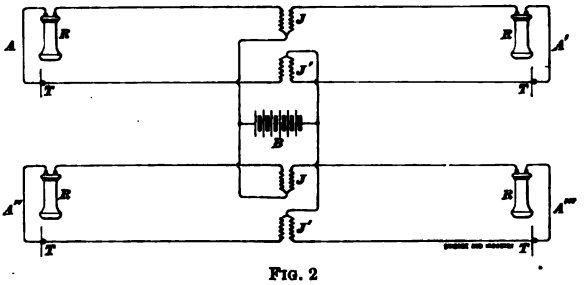

FIG. 2

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coils are wound on the same iron core. At the subscribers' stations the transmitters and receivers are shown, connected simply in series for the sake of simplicity, but, as a matter of fact, the arrangement is quite different, as will be shown later. When the

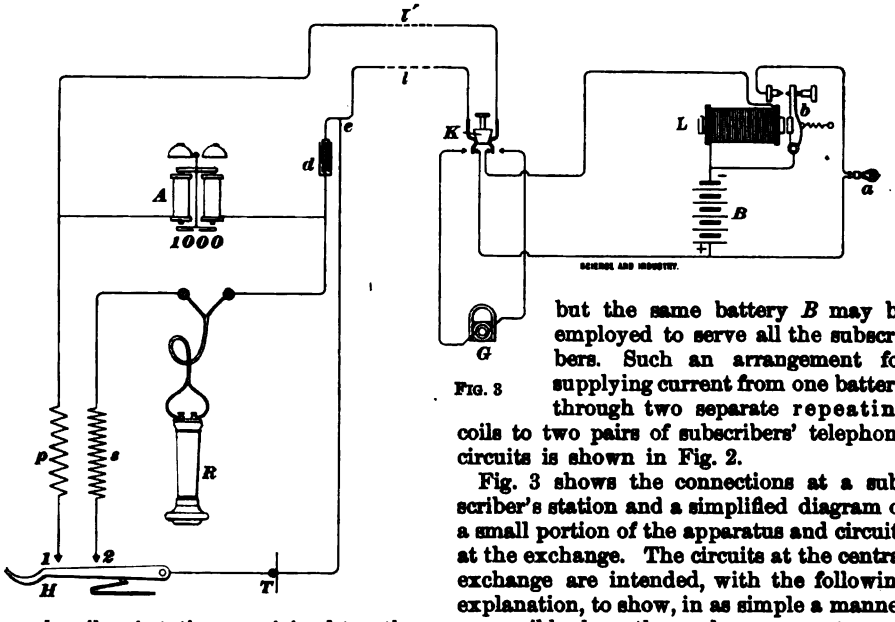

FIG. 3

two subscribers' stations are joined together through the central-exchange apparatus, the current from the positive pole of the common battery B will divide and pass through the separate windings j and j' of the repeating coil J to the line wires leading to subscribers' stations A and A'. The two portions of the current will then proceed through the apparatus at the two subscribers' stations, and return to the central exchange through the winding j and j' of the repeating coil J' to the negative pole of the battery B.

The action of one circuit on the other is quite simple. The two circuits may be considered as entirely separate, connected inductively only through the windings of the repeating coil. If the transmitter at station A varies in resistance, the current flowing from the battery B through the circuit of that line will be correspondingly varied. These variations, passing through the windings j, j of the repeating coils, will act inductively on the windings j', j', which are in circuit with the station A'. Any fluctuations in the current in the circuit through station A will induce similar fluctuating currents in the circuit through station A', and vice versa. When station A' is transmitting, the coils j, j act as primary coils, j', j' being the secondary coils. This is reversed when station A' is transmitting.

At an exchange a separate repeating coil must be used in each pair of cord circuits, but the same battery B may be employed to serve all the subscribers. Such an arrangement for supplying current from one battery through two separate repeating coils to two pairs of subscribers' telephone circuits is shown in Fig. 2.

Fig. 3 shows the connections at a subscriber's station and a simplified diagram of a small portion of the apparatus and circuits at the exchange. The circuits at the central exchange are intended, with the following explanation, to show, in as simple a manner as possible, how the exchange operator can call up a subscriber, and also how a subscriber is enabled to call up the operator.

When the receiver is on the hook, contacts *1* and *2* are open, and the only path for a current is from battery B through line l, condenser d, magneto bell A, and back through line l' to the battery. Current from battery B, which is constantly connected to the lines l, l', cannot, therefore, on account of this condenser, flow through the circuit just traced. The depression of the ringing key K by the telephone operator at the central exchange disconnects the two line wires l, l' from battery B, and connects them to the alternating-current generator G, called the ringing generator. Now, an alternating current can flow through a condenser; hence, when the key K is depressed, a current will pass over line l, through the condenser and the magneto bell A, back through the line l' to the generator G, and thus ring the bell A.

Suppose, now, that the connections are in their normal condition, and that the subscriber desires to call up the central exchange. All the subscriber has to do

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is to remove his receiver from the hook and when the operator answers give the number of the subscriber desired. When the subscriber removes the receiver from the hook the contact points *1* and *2* make connection with the lever *H*. This connects the two line wires *l*, *l'* together through the transmitter *T* and the primary winding *p* of the induction coil. This circuit has such a low resistance that it allows enough current from the battery *B* to flow over the circuit to operate a relay *L*, which is connected in series with the battery, as shown. The path of this current may be traced as follows: From the positive pole of battery *B* through line *l*, transmitter *T*, primary coil *p*, line *l'*, relay *L*, back to the negative pole of battery *B*. The relay, being energized, attracts its armature *b*, and thus closes a local circuit containing the signal lamp *a*, around the same battery *B*. This causes the signal lamp to light up and so calls the attention of the operator to this line.

The operator, on learning the subscriber wanted, connects the circuit, as shown in Fig. 4, over which the talking takes place. The subscribers' bells have been omitted in this figure. As previously explained, battery *B* supplies current for both microphones. The steady current from the battery at the central station passes only through the transmitter and the primary coil *p* at both stations. The variation produced in the resistance of the transmitter by talking against it transforms this steady current into a fluctuating current, which affects the distant receiver in a manner that will be explained.

When the receiver is removed from the hook switch, the latter closes not only the circuit containing the primary coil *p* and the transmitter *T*, but also connects the primary and secondary coils together at the contact points *1*, *2*. Starting from the point *e*, Fig. 3, there are three circuits to the line *l'*: one through the condenser *d* and the bell *A*; another through the condenser *d*, receiver *R*, secondary *s*, and primary *p*; and the third through the transmitter *T* and primary coil *p*. It will also be noticed that the transmitter *T*, secondary *s*, receiver *R*, and condenser *d* form a circuit by themselves.

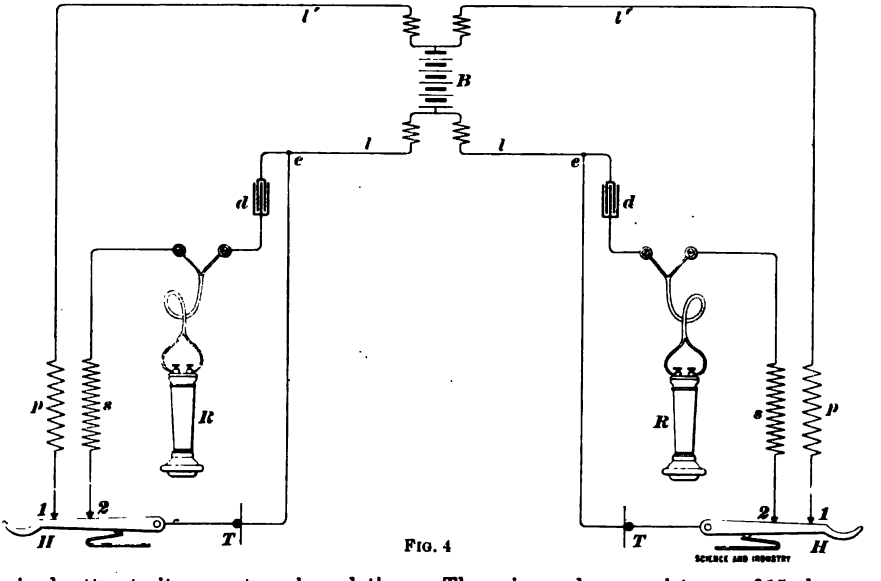

FIG. 4

The primary has a resistance of 15 ohms and the secondary 30 ohms, and these two coils are so wound and connected relatively to each other that a current through the two in series will be flowing in opposite directions in the two windings, and therefore will partially neutralize each other's effect on the iron core. Consequently, the induction coil does not tend to choke back an alternating current that flows through both coils in series, except in so far as the secondary, having more turns, is still able, with the same current, to magnetize the iron core somewhat.

With the hook switches in position shown in Fig. 4, battery *B* supplies a steady current to both transmitters. As the resistance

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of the transmitter T is varied by talking toward it, the steady current is changed into a fluctuating current. This fluctuating current in p induces an alternating electromotive force in s, which sends an alternating current through s, R, d, T, lever H, and back to s. The fluctuating current produced by the transmitter also acts on the repeating coils at the central station, producing in the other line circuit fluctuating, or voice, currents, as they are frequently called.

The voice currents coming from the distant subscriber's station over line l' will pass through the primary p and at the contact 1 will divide, part of it flowing around through the transmitter T and part through the secondary s, receiver R, and condenser d, reuniting at e, and returning over line l to the other station. The part that flows through the receiver circuit is opposed only by the ohmic resistance of the secondary and receiver coils, because the condenser d neutralizes more or less the choking effect due to the self-induction in the receiver and induction coils. Such a part of the current through p as may flow through the transmitter and not through the receiver circuit, will induce an electromotive force in the secondary coil s, which will cause a current to flow through the circuit, including the receiver, condenser, and transmitter. This induced current is in unison with that part of the current from the main line that flows through the receiver circuit. The combined effect of these two currents (if they can be so called) is sufficient to properly affect the receiver R.

It may be well to add that the bell A, shown in Fig. 3, is wound to a resistance of 1,000 ohms with fine wire, and on account of its high inductance offers such a high apparent resistance, or impedance, as it is called, to the very rapidly fluctuating voice currents that they cannot pass through it.

Several arrangements of the apparatus at a subscriber's station have been tried, but the one described above and now used extensively by the American Bell Telephone Company has apparently given the best satisfaction.

PROF. D. E. HUGHES

H. S. W.

ON JANUARY 22, Prof. D. E. Hughes died in England at the age of 69 years.

He was born in London in 1831, and when 7 years old came to this country with his parents. When quite young he developed great musical ability, and was appointed Professor of Music in the College of Bardstown, Ky. He was also an ardent student of physics and mechanics, and at the age of 19 was appointed to the chair of Natural Philosophy in the same college in which he held the professorship of music.

While at this institution, Professor Hughes developed his first important invention—the world-renowned type-printing telegraph, which was patented in this country in 1855. In less than two years it was adopted by several telegraph companies in America, and shortly afterward by nearly all the European governments. England, the last country to appreciate the type printer, recognized its merits in 1863. For this invention the inventor received prizes, medals, and membership in nearly all the great orders of the European governments.

Professor Hughes made many discoveries in practical and theoretical science, and gave free to the world the principle on which all telephone transmitters of the present day depend. Although Berliner, Edison, and Gray, a year or so before the publication of his paper, had devised battery transmitters, it is doubtful whether they understood the true principle of the instruments. By his contributions to electrical science, Professor Hughes won fame, medals, and honors from many learned societies. His most noted paper is probably the one on the experimental theory of magnetism. It is also claimed that he was the first to discover the essential principle of wireless telegraphy, but unfortunately he did not publish his discovery until last May. The paper, however, furnished the best evidence in support of his claim to have been the first to transmit actual signals over a considerable distance by means of electrically generated ether waves.

In 1886, Professor Hughes was President of the Institution of Electrical Engineers, of England, where he lived the greater part of his life. His inventions yielded him a good income, and hospitals and other charitable institutions were generously remembered in his will.

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STEEL-ROOF INTERSECTIONS

Maurice M. Sloan

PURLIN AND RAFTER CONNECTIONS—OBTAINING THE FLANGE AND WEB CUTS FOR THE BEAMS. DEVELOPING THE BENT BRACKETS

IN LAYING out the shop drawings for steel construction, there is nothing so troublesome as the intersections of a hip roof, in which it is required that the connections be neatly formed. The imagination of the draftsman is tried sorely, and if he does not resort to the kindergarten methods of wood and paper models, his training in descriptive geometry is better than is usually the case. In fact, the writer has seen many instances, in drafting-room practice, where the expense of making such drawings was no small item in the cost of the entire work, and especially was this so where the work was of the light description so common in iron and steel roofs as ordinarily constructed. It is, therefore, for those that have had such problems to deal with that the following is presented, and it is hoped that the information given may be of use in all similar problems.

In Fig. 1 is shown a diagrammatic view of the plan and slope of the roof, with the

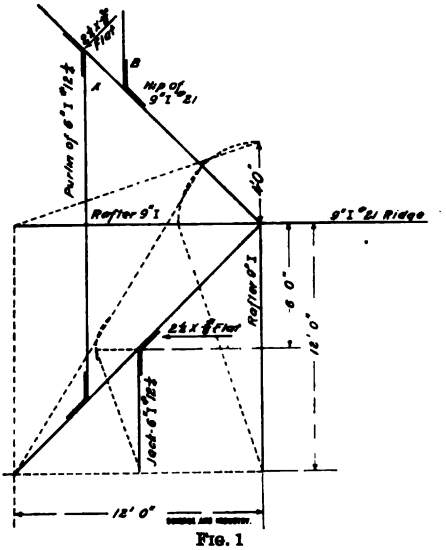

FIG. 1

intersections at *A* and *B* with which it is proposed to deal. The purlins and rafters are 6-inch I beams, weighing 12¼ pounds per foot, and are to be framed to the hip member flush with the top flange, by means of ⅝″ × 2½″ bent-plate brackets, bolted with ¾-inch bolts. The relative sections and the several dimensions of the beams are shown in Fig. 2.

One unfamiliar with such intersections, on first considering the problem, is apt to form erroneous conclusions, and might think that, though the flange of the purlin at *A*, Fig. 1, is cut on a bevel, the web will be cut plumb or square, and that the bent-plate bracket will be simply a flat bar bent to the angle shown on the plan. That this is not the case is shown by a glance at Fig. 4 (*a*) and (*b*), which show the peculiar shape required at the end of the purlin in order that it may fit snugly against the hip member, and the angular form required by the development of the bent-plate bracket so that the edge of each leg will run parallel with the hip and purlin, respectively.

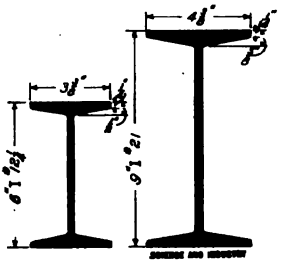

FIG. 2

It is necessary, therefore, in obtaining the correct cutting angles, or bevels, and the development of the bent-plate bracket, to lay out such a diagram as is shown in Fig. 3. From this figure, which applies to the purlin only, measurements can be taken that will give the required angular, or bevel, cut, a similar layout as in Fig. 5 being required for the rafter. The method of obtaining these measurements may be described and explained, in conjunction with Fig. 3, as follows: Lay out the plan of the corner *a b c*, and draw the center line *b d* of the hip, on which construct, to any scale, the web of the hip beam, and also the line *e f*, which represents the flange edge of the same member. From *a*, draw the line *a k*, which represents the roof slope, and, normal to this slope, draw the section of the purlin, to the same scale used in marking off the web and flange lines of the hip; this section is as designated at *g h i j*. Through these points project lines

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parallel to the direction in which the purlin extends, until they intersect the hip at $l m n o$. The lines $g l$ and $h m$ stop at the flange line of the hip, on account of the top flange of the purlin framing flush with the upper flange of the hip, while the lines $i n$ and $j o$ are prolonged to the web of the hip, that being where the lower flange of the purlin abuts this member. All distances along these lines are true measurements, and, consequently, by drawing the line $p q$ through the point r, and measuring from it the distances $s m$ and $u l$, the bevels, or the cuts on the web and both flanges, of the purlin can be obtained. For instance, at Fig. 4 (a), the bevel on the flange is ascertained by making the distance $w l$ on the

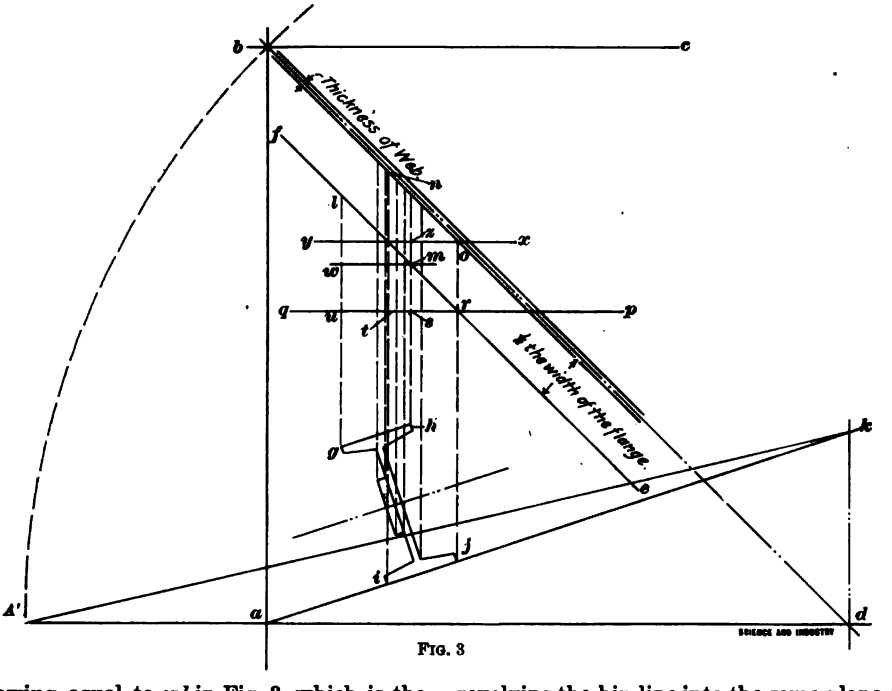

FIG. 3

drawing equal to $w l$ in Fig. 3, which is the difference in length between $s m$ and $u l$. In like manner, the distance $s m$, or the bevel cut of the web at Fig. 4 (a), is obtained from Fig. 3 by measuring the distance $s m$ on this diagram. The distance $z m$ on the true plan of the working drawing, Fig. 4 (a), is equal to the distance similarly marked in Fig. 3, which is obtained by passing through the point o the line $x y$ and measuring the distance $z m$. The distance a in Fig. 4 (a) can be made equal to the flange thickness of the hip where it joins the web, which in this instance is $\frac{5}{8}$ inch. The web is then cut back from the point b to the intersection of the web with the bevel cut of the upper flange.

The development of the bent-angle plate, or bracket, now requires attention, and, as before mentioned, it must be so laid out that, when it is bolted in place, the legs will be parallel with the member to which they are secured. The bevel or angle $c d k$, Fig. 4 (b), along which they are bent, is the same as the bevel cut on the face of the web, and can be obtained from Fig. 3 in the same manner. The angle $a' k a$, Fig. 4 (b), to which the plate is cut, is the difference between the angle that the hip makes with the vertical and the angle of the roof slope. This angle can be obtained from the diagram, Fig. 3, by revolving the hip line into the same plane as the roof slope and measuring the angle $A' k a$ in this figure. The plate is bent to the same angle as the bevel cut of the flange, which can readily be seen from Fig. 4 (a).

Working from Fig. 3 in this manner, all the cuts, as well as the development of the bent-plate bracket for the purlin, can be obtained, and the working, or shop, drawing made, as shown at Fig. 4 (a) and (b). Any measurements that may be required to properly designate the twist or bends of the bent-plate bracket, when bolted in position, can readily be obtained by projecting from

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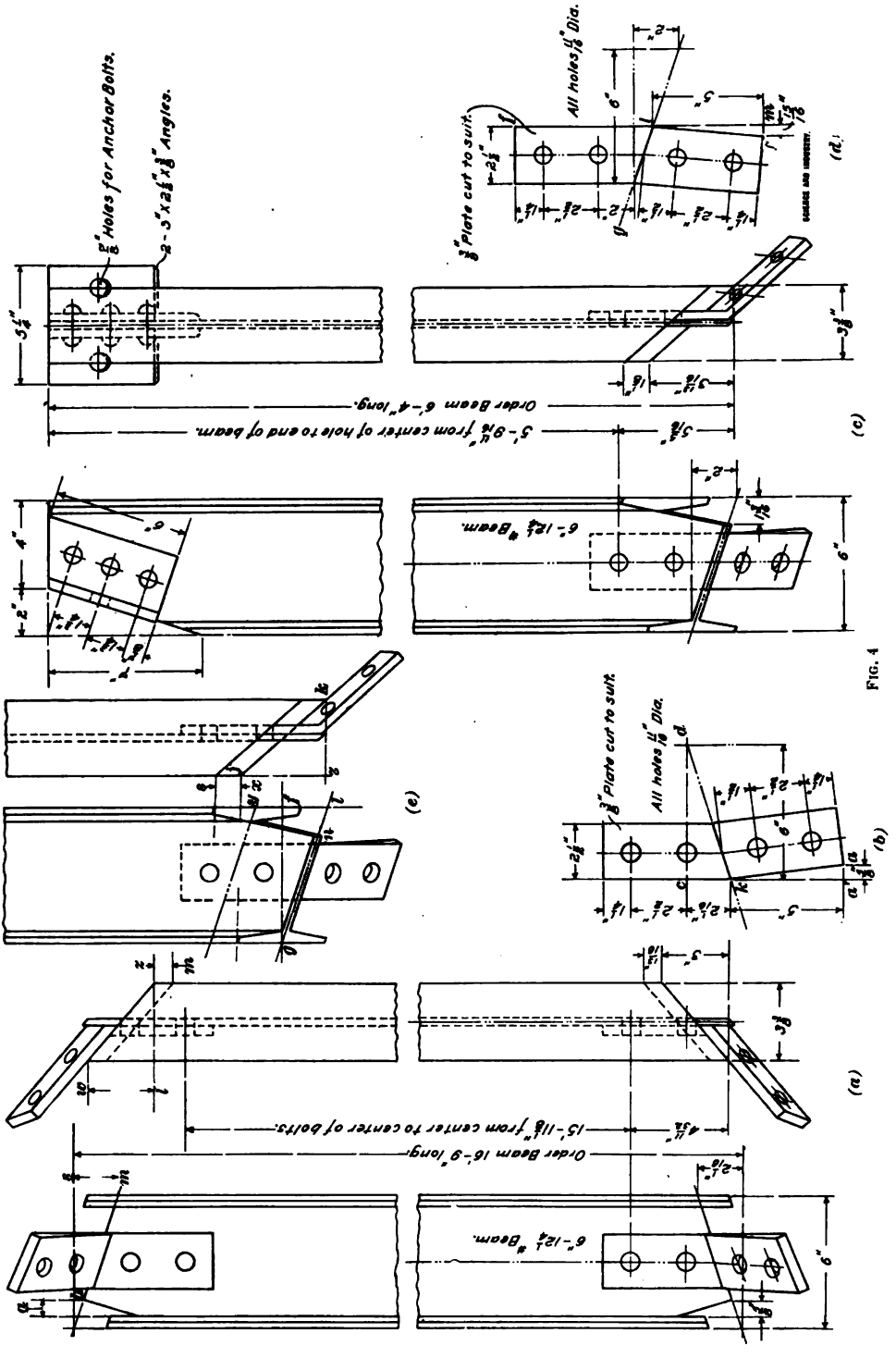

FIG. 4

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the corners of the bent plate, as shown in section in Fig. 3, lines intersecting the web of the hip; in fact, employing the same method as in finding the web and flange cuts.

The cuts and the development of the bent-plate bracket for the rafter *B*, Fig. 1, are obtained somewhat differently, as reference to Fig. 5 shows. From this diagram, the cuts for the flange and web, and the angles for the development of the bracket, may be obtained as follows: Draw the outline *a b c*, which represents the corner of the building, and on the center line of the hip *b d*, mark off the width of the web and flange on the side next to the rafter. Designate the rafter as at *f g*, and project *i h* on the slope of the

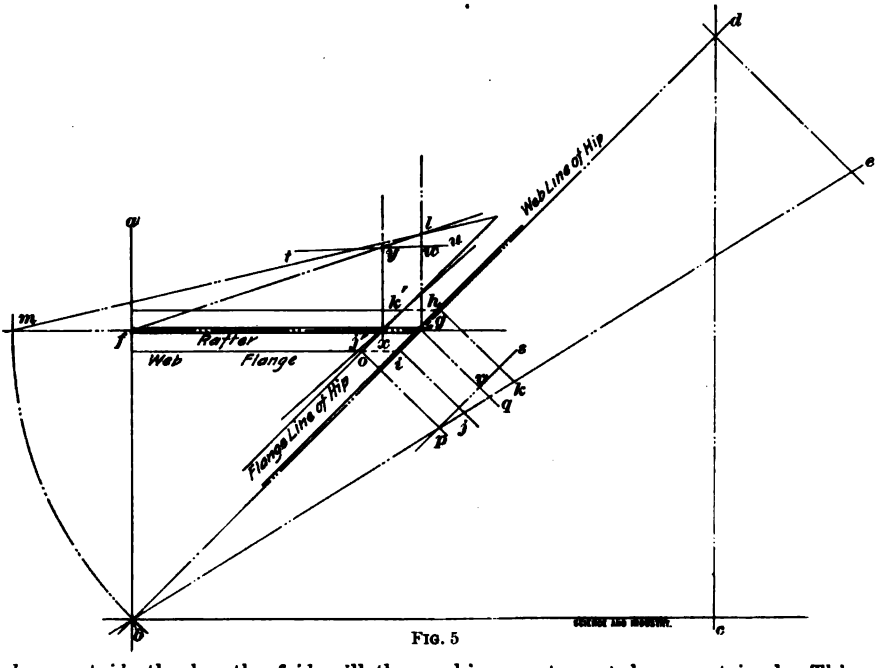

FIG. 5

the required angle from which the cut *f l g* on the web, Fig. 4 (*e*), is laid out.

The distance *s x*, on the plan, Fig. 4 (*e*), that the lower flange extends beyond the upper, is also obtained from Fig. 5 in this manner: Project the vertical upward from *x* until it cuts the line representing the slope of the rafter at *y*; then the distance *y l* must be laid off on the center line of the upper flange, as at *y l*, Fig. 4 (*e*), and the section drawn. The distance *s x* may then be determined by projecting the points in the web view to the flange, or plan, view, and scaling.

The distance *l n*, Fig. 4 (*e*), that it is necessary to cut away the web in order that it may fit under the flange of the hip *b e*, as at *j k*; the length of *j k* will then be the length of the flange cut of the rafter. By laying this distance *j k* across the flange of the rafter, as at *j' k'*, the angle for the flange cut can be obtained, and marked on the working drawing of the rafter, as at *j k z*, Fig. 4 (*e*).

The web cut of the rafter is a plumb-cut; that is, when the rafter is in place the web is cut perpendicular to the horizontal, and, consequently, the angle that the cut makes with the flange is the angle *f l g*, Fig. 5. This angle is obtained by drawing from the heel of the rafter the line *f l*, which represents the true slope of the rafter; the angle this line makes with the vertical line *l g* is

hip, must next be ascertained. This can readily be accomplished by projecting *o* and *g* on the line *b e*, which represents the slope of the hip, considering *b d* as the horizontal, as at *p* and *q*. Draw the line *p s* parallel with *b d*, and measure the distance *q v* on the line *g l*, as at *l w*, and the line *t u*, which is drawn through the points *y* and *w*, will be the slope across the flange of the hip in the same plane as the web of the rafter member. Then, by adding to this distance *l w* the thickness of the flange of the hip, which is $\frac{5}{8}$ inch, the distance *l n* on the working drawing can be marked off. From the point *n* just obtained, the web is cut back, as was done with the purlin.

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The angle flg around which the plate bracket, Fig. 4 (d), is bent, can be obtained from the angle flg, Fig. 5, being the same angle as that to which the web of the rafter is cut. The angle mlf', Fig. 4 (d), which one leg of the bracket bears to the other in the development, is obtained from Fig. 5; it is the difference between the angle made by the slope of the hip and the rafter with the horizontal, and is the angle mlf.

This completes the details of the rafter except the foot-cut, which is the angle lmf, Fig. 5. This cut is across the web, and the flange cut is a straight or square cut. Having obtained all the necessary angles for cutting and bending, the other dimensions can readily be determined by scaling the diagrams as laid out in Figs. 3 and 5; or, in the case of principal dimensions, they can be figured, trigonometrically if so desired, and the working drawing completed somewhat as designated in Fig. 4.

ANGULARITY OF THE CONNECTING-ROD

Chas. J. Mason

MEANING OF THE PHRASE—EFFECTS OF ANGULARITY—EFFECTS ON THE GUIDES—EFFECTS ON THE CUT-OFF—THE VALVE DIAGRAM

THE angularity of the connecting-rod is an expression that we frequently see in engineering textbooks, magazines, and papers, and yet, strange to say, we seldom find any explanation of what the expression means, what is affected by more or less angularity, and how, and to what extent.

It is very likely that, in many instances, the authors of the literature above referred to assumed that their readers knew enough of the subject to understand it, or else they did not consider it of sufficient importance to give it more than passing notice. Of course, there are many that do understand all about the subject; there are others that partially understand, and have a vague and clouded idea of what the term means, and what is to be considered in connection with it; and then, again, there are many that do not know anything at all about it. Perhaps it may appear at first sight to be an uninteresting subject, and many readers may be tempted to pass this article by without further notice than reading the title. Let us see whether it is worth while to give the subject any attention. It is to be hoped that the reader will be fully compensated for the time he spends in reading what is said about the angularity of the connecting-rod.

We will try to treat the subject from a practical standpoint, and in a practical manner, calling to our aid a diagram that shows everything pertaining to the subject of this article. It may be further stated that this diagram is peculiar to the slide valve only, not being applicable to an automatic cut-off engine of the Corliss type, so far as the point of cut-off is concerned. It is the purpose of this article to employ only such parts of the diagram as concern our subject.

We will first take up the meaning of the phrase "angularity of the connecting-rod." This simply refers to the fact that the connecting-rod makes an acute angle with the center line of the cylinder, an angle that varies with the stroke—that is, according to the relative positions of the crank. For instance, in Fig. 1 (a) and (b) is shown the angularity of the rod when the piston is at half stroke. The illustration further shows that the angularity depends on the length of the connecting-rod in relation to the stroke, which, in turn, is governed by the distance between the center of the stroke and the center of the shaft.

In Fig. 1 (a), the length of the rod is $2\frac{1}{2}$ times the stroke; when the crosshead is exactly in mid-position in the guides, or, as we say, at half stroke, the length of the rod from center to center will be equal to the distance between the center of the stroke and the center of the shaft. Now, with a pair of compasses, and taking the distance just mentioned as a radius, describe an arc cutting the circumference of the circle representing the path of travel of the crankpin, using the center of the stroke as a center from which to describe the arc. It will be noticed that the arc described with the radius given cuts the crankpin circle at points some little distance from the vertical center line. This distance is governed by the angularity of the connecting-rod. Again, referring to Fig. 1 (b), it will be seen that

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the length of the rod is given as 1½ times the stroke, and by repeating the operation shown in Fig. 1 (*a*), we find that the distance from the vertical center line (at which the arc described with the connecting-rod as a radius intersects the crankpin circle) is greater than before. This is because the rod in the second case is shorter—the distance between the center of the stroke and the center of the shaft being less than that of Fig. 1 (*a*). Transferring the connecting-rod of Fig. 1 (*b*) to Fig. 1 (*a*), it is apparent that the shorter the connecting-rod, the greater the angle between the connecting-rod and the horizontal center line. From Fig. 1 (*a*), we see that the shorter the rod, the greater the angularity; conversely, the longer the rod, the less the angularity.

If it were possible to conceive of an engine having a connecting-rod that would always move in a parallel plane at all parts of the stroke of the piston, and at all positions of the crank—that is, if the connecting-rod would, while turning the crank, remain parallel to the horizontal center line—then the effects produced by angularity would cease to exist.

The first effect of angularity that we will speak of is the pressure produced on the guides in which the crosshead runs. It may be stated thus: the shorter the connecting-rod, the greater will be the pressure on the guide. The maximum pressure on the guide bears the same proportion to that on the piston as the length of the crank bears to that of the connecting-rod. As an illustration, let us take the following:

It is required to find the greatest thrust on the guide when the total pressure of the piston at half stroke is, we will say, 15,000 pounds. The radius of the crank is 12 inches, and the length of the connecting-rod is twice the stroke, or 48 inches; then the maximum thrust is $\frac{15{,}000 \times 12}{48} = 3{,}750$ pounds, which is the *total* pressure on the guide, not the pressure per square inch. Now, it will readily be seen that if the rod were shorter, the divisor in the above formula would be less, and, consequently, the lesser number would be contained in the dividend a greater number of times, and the quotient would, therefore, be greater than before. Perhaps to some readers the above will be easier to understand if stated as follows:

As the length of the connecting-rod is to the length (or radius) of the crank, so is the total pressure in pounds on the piston to the total pressure in pounds on the guide when the piston is at half stroke. Expressed in figures, it is as follows:

48 : 12 :: 15,000 : 3,750.

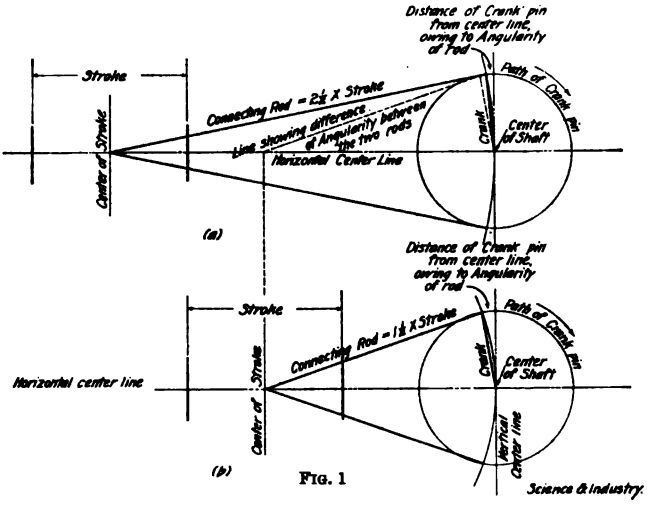
Distance of Crank pin from center line, owing to Angularity of Rod
Path of Crank pin
Stroke
Connecting Rod = 2½ X Stroke
Line showing difference of Angularity between the two rods
Crank
Center of Shaft
Center of Stroke
Horizontal Center Line
(a)
Distance of Crank pin from center line, owing to Angularity of Rod
Stroke
Path of Crank pin
Connecting Rod = 1½ X Stroke
Crank
Center of Shaft
Horizontal center line
Center of Stroke
Vertical Center line
(b)
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FIG. 1

The second effect of angularity of the rod is that the piston must travel beyond its mid-position in order that the crank may reach its mid-position; or, in other words, the piston will have traveled farther than half stroke when the center line of the crank is at right angles to the horizontal center of the engine in the case of a horizontal engine, or to the vertical center line in the case of a vertical engine.

The third and last effect that we shall deal with in this article is probably the most important, and may be stated thus: In an ordinary simple slide-valve engine, with equal leads and laps at both ends of the valve, the points of cut-off will not be the same for both strokes. Therefore, if it is desired to have the steam cut off when the piston has traveled a certain distance from each end of the cylinder, it will be necessary to increase the lap at the head-end (sometimes called the *back end*), or, in the case of a vertical engine, the top end; and, likewise, if it is desired to have an equal amount of compression at both ends of the stroke, the exhaust lap will have to be increased at the crank or bottom end. The altering of the amount

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of lead at both ends will also tend to equalize the cut-off. A careful study of the diagram, Fig. 2, will show how these changes may be wrought, and just how the angularity of the rod affects the movement of the valve. If it were not for angularity, equal leads and laps would produce equal points of cut-off in the stroke at both ends of the cylinder.

Let us look into the construction of the diagram, Fig. 2, and the points of interest it contains. The construction of the figure is as follows: Draw a center line *A B*, and at some distance from the end *B* draw the line *C D* intersecting *A B*, and at right angles to it. From the point of intersection *O* as a center, and with a radius equal to one-half the travel of the valve, describe the circle *E F G H*; from the same center *O*, describe the smaller circle *I J*, whose radius is equal to the proposed lap of the valve; at the points *B* and *H*, on the center line *A B* where the circle *E F G H* intersects it, describe circles whose radii equal the proposed leads, which we will say is $\frac{1}{8}$ inch at each end. Now, draw a line *H G* tangent to the lead and lap circles; likewise, draw, on the other side of the figure, the line *E F* tangent to the lap and lead circles on that side.

Let the circle *E F G H* also represent the path of travel of the crankpin (to a reduced scale), and divide the diameter on *H B* into as many parts as there are inches in the stroke—in this case 24. The diameter of *E F G H* now represents the stroke of the engine, and the radius equals the length of the crank.

At the points *E* and *G* in the circle *E F G H*, where the lines tangent to the lead and lap circles intersect it, will be the positions of the crankpin at cut-off, respectively; the crank is represented in its respective positions by the lines *E O* and *G O*. The travel of the valve, the amount of lead, and the amount of lap given determine the position of the tangent lines above referred to (*E I F* and *H J G*); and the points of their intersection in the circle *E F G H*, at the points *G* and *E*, in turn determine the position of the crank when the steam is cut off in the cylinder.

If the connecting-rod did not make an angle with the horizontal center line, or, in other words, if we leave the angularity out of account, then the points of cut-off in the stroke will be found by drawing the lines *G Q* and *E P* parallel to the vertical center line *C D*, showing an equal cut-off at both ends of the cylinder; in our diagram this takes place so close to the figure *17* at one end and *7* at the other that we would say

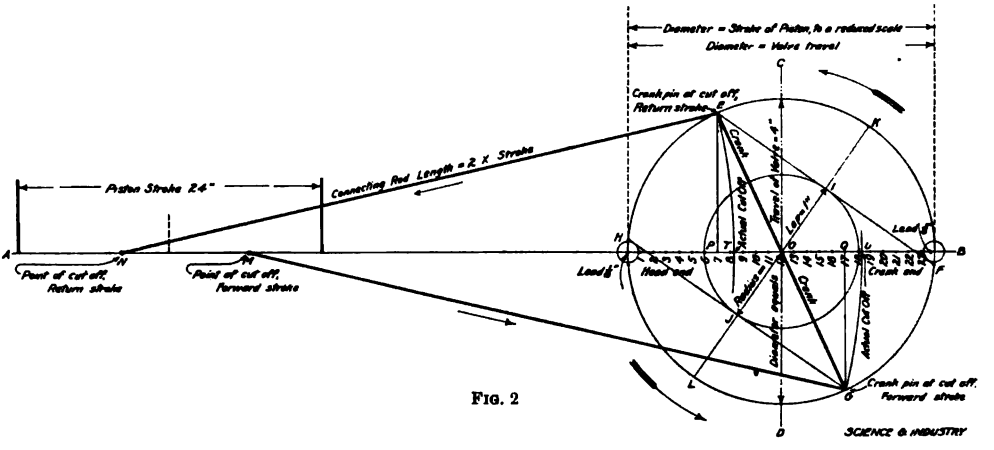
Diameter = Stroke of Piston, to a reduced scale
Diameter = Valve travel
Crankpin at cut off, Return stroke
Crank
Travel of Valve = 4"
Actual Cut Off
Lap = 1"
Lead
Piston at 11
Crank end
Piston Stroke 24"
Connecting Rod Length = 2 X Stroke
Point of cut off, Return stroke
Point of cut off, Forward stroke
Head end
Diameter equals Stroke
Crankpin at cut off, Forward stroke
SCIENCE & INDUSTRY

FIG. 2

that cut-off takes place after the piston has traveled 17 inches of its stroke.

But, to be correct, we must take the angularity of the rod into account, and this is the way we proceed. The length of the rod is taken, in this case, as twice the stroke, 48 inches. As the diameter of the circle *E F G H* equals the length of stroke, to scale, twice the diameter will be the length of the connecting-rod, also to scale. Now take a pair of compasses set to the length of the rod, and from the center *G* (position of crank at cut-off on the forward stroke), strike an arc intersecting the center line *A B* at *M*; also from the center *E* (position of crank at cut-off on the return stroke), strike an arc intersecting the line *A B* at *N*; now reverse the operation by using the points *M* and *N* as centers—still using the length of the rod for a radius—and strike arcs intersecting the

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line representing the stroke at the points *U* and *T* respectively. These points represent the actual points of cut-off when the angularity of the rod is taken into account.

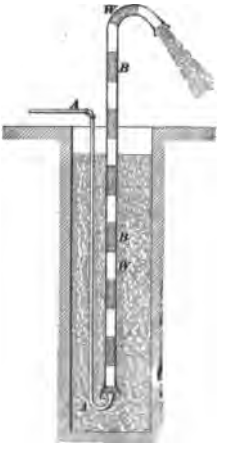
In order to have an equal cut-off at both ends, and also equal leads, it can be seen from the diagram that we would have to *increase* the lap at the head-end, or decrease that at the crank-end. Decreasing the lead at the crank-end will also, to a small extent, tend to equalize the cut-off.

If it is desired to show the effect of angularity on the opening and closing of the valve to the exhaust, small circles may be described from the common center *O*, with a radius equal to the amount of exhaust lap. By going through the same procedure as before explained, all in connection with this part will be revealed. It may be stated thus: In order to have equal points of cut-off at both ends of the cylinder, it will be necessary to have more lap on the head-end of the slide valve than on the crank-end; and to have the valve open and close to the exhaust at equal points of the stroke at both ends, it will be necessary to increase the exhaust lap at the crank-end. The amount of increase in each case can be determined by the diagram in question.

A careful study of this diagram should remove all the perplexity occasioned by questions concerning the slide valve and the angularity of the connecting-rod.

A VALVELESS PUMP

COMPRESSED air may be made to lift water through the medium of a valveless pump, and the mode of action may be understood by bringing to our assistance the figure that accompanies this description. The first peculiarity about it is that the elevation of the orifice of delivery above bears a certain proportion to the depth of the orifice of intake below the water level, or otherwise the pump does not act efficiently. The proportion of elevation for delivery is found to be as 2 when the depth of the orifice of intake is 3, or the pump is most effective in its action when the proportion of elevation above the water level is $\frac{2}{3}$ of the entire length of the pipe. The mode of action is something like this: From the orifice of intake to the orifice of delivery the combination column of air and water weighs less than the head of water measured from the orifice of intake to the water level, or a column of water whose length is 3 must weigh rather more than the combination column of air and water whose length is 5.



Most likely for a rapid discharge, the proportion will be as 2.5 to 5; that is to say, a combination column of air and water whose length is 5 will be equal in weight to a column of water whose length is $2\frac{1}{2}$, thus providing a motive column of .5 to overcome friction and produce motion. To make the combination column, compressed air is blown into the column within the pipe, near its lower end, and at a pressure little greater than that due to the water head. This air displaces a portion of the water within the column, and breaks it up into cylinders that consist alternately of air and water; the result is that the combination column of air and water that extends from the orifice of intake to the orifice of delivery is lighter than the column of water that extends from the orifice of intake to the water level. The air cylinders are at first very short, but as the column moves upward and the pressure of the overhead column reduces, they lengthen by expansion until at the moment of discharge they are much longer than the water cylinders. Hence, this accounts very much for the reduced weight of the column. This pump is very useful where a sufficient length of immersed column can be obtained. By reference to the figure, the water pipe is seen at *W* and the compressed-air pipe at *A*.

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SOME DETAILS OF CONSTRUCTION

Constructor

THE WALLS—COLUMNS—FLOOR GIRDERS—FLOORING AND CORNICE CONSTRUCTION OF A FACTORY BUILDING OF MODERATE COST AND GOOD CONSTRUCTION

A FACTORY building, while it offers a small field for architectural treatment from an artistic standpoint, requires careful consideration and adaptation of much experience to attain the best results along the lines of utility and stability.

The requirements of the manufacturer are many. He must have plenty of free floor space, the floor must be stiff, and its vibration under moving machinery slight. The window openings must be adequate, and so placed as to completely light the interior, and they must be so arranged that heavy shadows from the columns or interior supports of the building are eliminated. Also, in order that the manufacturer can obtain the lowest rates of insurance upon his machinery and materials, the construction must be either of the so-called slow-burning type, or better still, that known as fireproof. It may be that both of these features are to be combined in the one building, because of the manufacturer requiring in his processes the use of furnaces or forges, or the handling of some very combustible material.

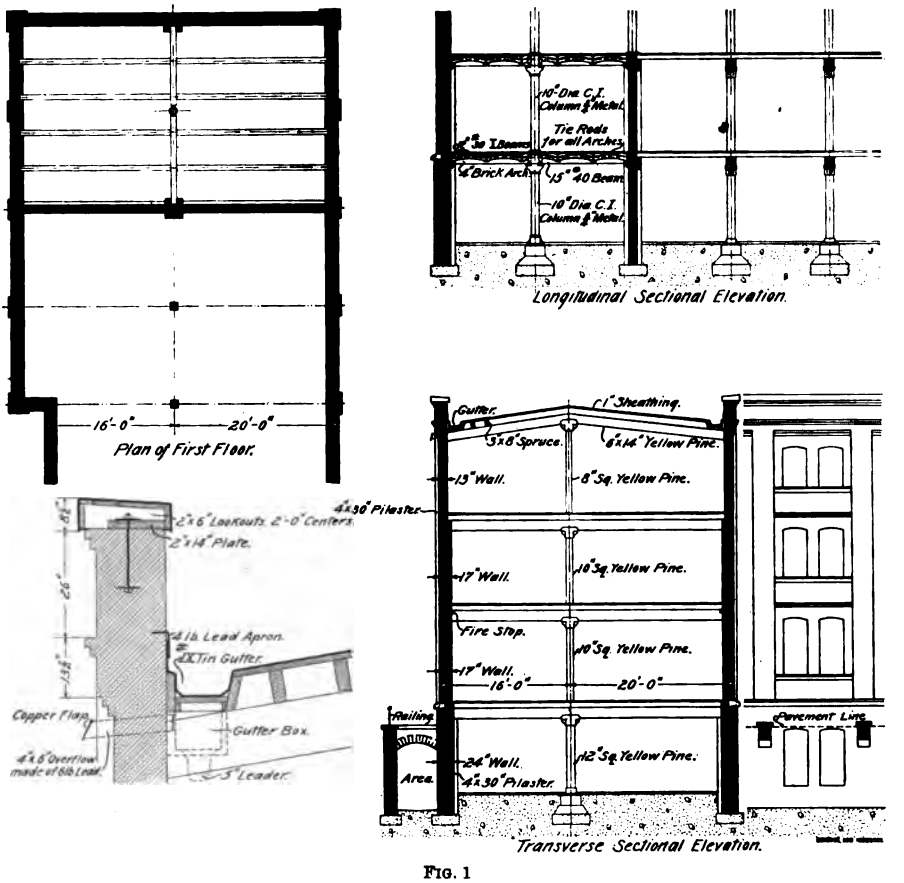

FIG. 1

Such conditions had to be fulfilled in the design of the building shown in the accompanying sketch, Fig. 1. This building was

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to be three stories in height, with brick walls and concrete foundation. It was a much-debated question whether the main girders of the building should be I beams, amount of headroom that they occupied. They were also objected to because there was to be erected in the building much shafting, both line and counter, and it was imperative

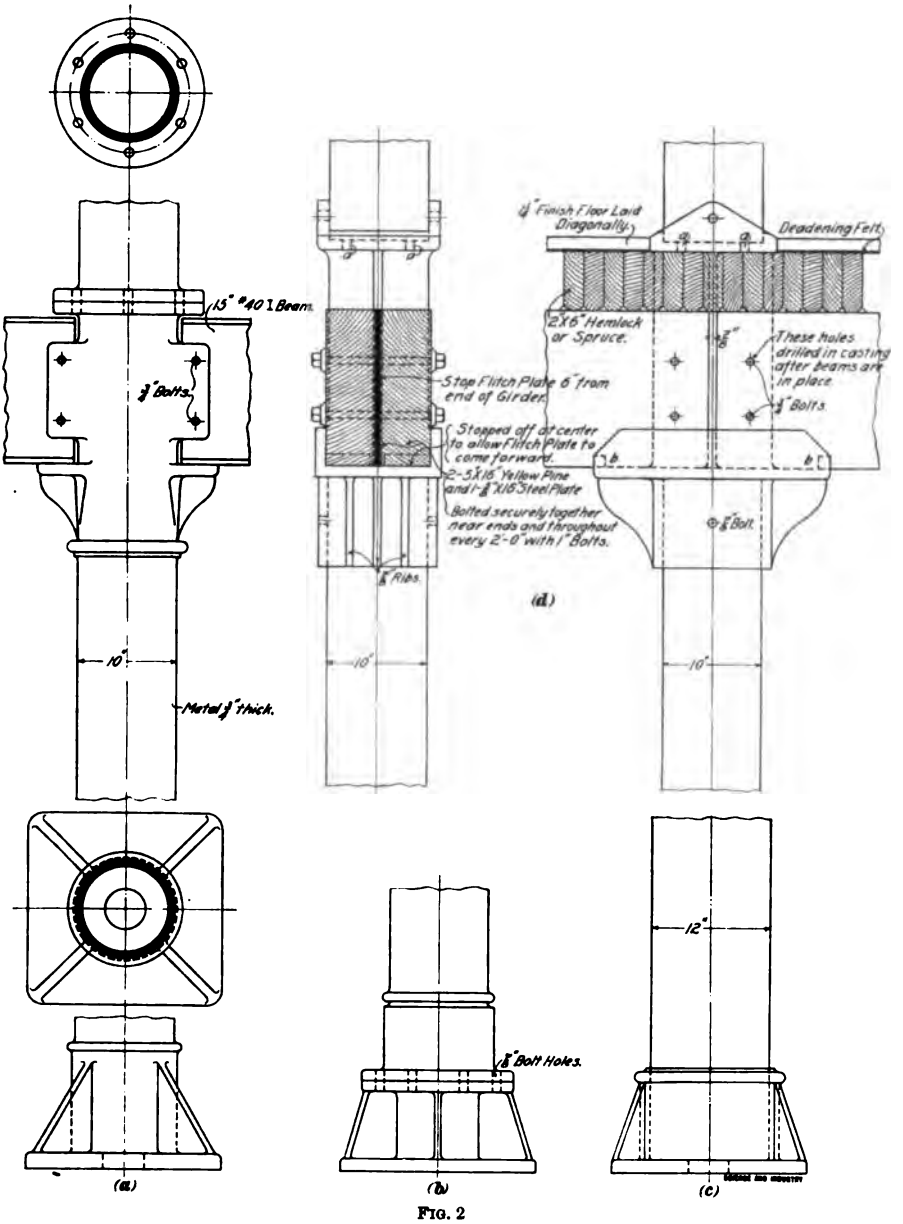

FIG. 2

trussed wooden girders, or flitch-plate girders. It was thought inadvisable to use the I beams except in the fireproof section, and the objection to the trussed girders was the that the girders should offer a flat surface for the proper securing of the hangers. All things being taken into account, it was concluded to use the flitch-plate girder shown

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at Fig. 2 (*d*). One of the cogent reasons for using these girders was the fact that on the 16-foot span, necessitated by the plan of the building, the flitch plate in the girder could be omitted, and a solid wooden girder, of the same dimensions as the compound girder, substituted.

The columns were designed to carry a floor load of 200 pounds per square foot upon all floors; this included the dead and live loads. The columns supporting the roof were made unnecessarily large for strength, so as to meet the requirements of slow-burning construction. The flitch-plate girders were connected to the cast-iron cap resting on the lower column and supporting the upper one, the cap being somewhat after the pattern of the Goetz-Mitchell construction. It will also be noticed that holes were left in the castings at *a*, *a* to allow ventilation and drainage for any sap that might remain in the timber. The girders were secured to the web of this casting by two ¾-inch bolts running through the timber but not through the flitch plate, which was stopped off 6 inches from the center, so as not to interfere with the web. These bolts, with the check-pieces *b*, *b*, and wall boxes of the Goetz-Mitchell type, at the other end of the girders, made lateral motion in the building impossible.

The particular purpose for which this building was designed required that machinery could be located at any point upon the floor, and as the machinery was rapidly moving, and likely to produce considerable vibration, it was decided to introduce a rough floor made of $2'' \times 6''$ hemlock, 24 feet long, spiked together on edge so as to break joints and span two bays. Such a system of rough flooring produced a solid slab of wood, 6 inches thick, continuous throughout the floor. The finished flooring was laid diagonally upon the top of this, with deadening felt between as a protection against the percolation of water from the floors above in case of fire or leakage, besides acting as a deadener. The diagonal flooring greatly stiffened the building, and facilitated the wheeling of heavy trucks over it without causing material wear and tear. The cost of the heavy rough flooring, when compared with the $3'' \times 12''$ joists placed at 12-inch centers, was about twice as much; that is, the joists cost, approximately, 9 cents per square foot of floor surface, while the $2'' \times 6''$ pieces, side by side, cost 18 cents, the prices including labor. The owner, however, was fully satisfied to pay the increased cost when he realized the immense advantage accruing from the solid floor construction.

The fireproof section of the building was cut off from the main portion by a 12-inch curtain wall. The construction adopted in this section consisted of cast-iron columns, steel beams with 4-inch brick arches, provided with cinder-concrete filling and cement-finished floor. The details of the columns were carefully studied, with the result that at first it was deemed advisable to use the column shown at Fig. 2 (*a*). However, a change was decided in the base of these columns, with the conclusion that it would be better to construct them as at (*b*). The reason for this change is obvious. The webs of the base, as at (*a*), would project above the cement floor, and would appear unsightly and always in the way; while if separate bases were used, as at (*b*), the cement floor could be carried above the bolt flange and the ribs of the bases would be entirely out of sight, buried in the concrete. There is an advantage to be gained in facility of erection by using the separate base. This advantage is that the bases can all be placed upon their piers or foundations and alined, being held in place with several light anchor bolts; the columns can then be speedily and accurately erected upon them.

The thickness of walls given in the drawing, Fig. 1, is ample, provided $4'' \times 30''$ external pilasters are built at each bay. By running sill and string courses between these pilasters at the proper heights, the verticality of the building is destroyed, and character is given to its façade, which a factory may as well possess as a building of more pretensions.

There is nothing so important about any building as the roof; in fact, the main reason for the existence of the building is to provide a shelter, and hence any building is merely a support for the roof. And, as the first requisite of a good roof is tightness, which can only be obtained by providing proper drainage for it, much attention should be paid to the gutter and its construction. The gutter should be wide, so that snow can be shoveled from it. It must have the proper pitch, which should be from 1 to 1½ inches in 10 feet. It should be made sloping on one side, so that, if ice forms, it readily frees itself and does not choke the channel. Overflows should be provided, for, if the leaders choke, the roof will become a reservoir, which, ten chances to one, will have its outlet down the inside of the walls, much to the detriment and

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pecuniary loss of the occupants and the owner. This overflow must at all times be clear of obstruction, and hence, in order to prevent birds from building therein, it is well to screen them inside and outside, or provide other means of protection from such undesirable tenants. The leaders from such a gutter should be carried down the inside of the building, and for this building two 5-inch cast-iron leaders, one on each side, were found ample.

There are many other things about this factory building that might be mentioned, but the drawings are so clear that a further explanation seems unnecessary. Although there are many methods of construction adapted to a building of this character, these few details and features of construction are given because the building erected according to this method fills the requirements of one owner, at least, as he expressed it, "to perfection."

CONTROL OF INCANDESCENT LAMPS FROM TWO OR MORE POINTS

ONE of the features that has contributed largely to the success of the incandescent light is the ease with which it may be turned off and on, either at the lamp itself or from some distant point. There are two or three special switching arrangements that are particularly useful, and, while they are not by any means new, they may be of interest to our readers, judging from the inquiries we frequently receive concerning them.

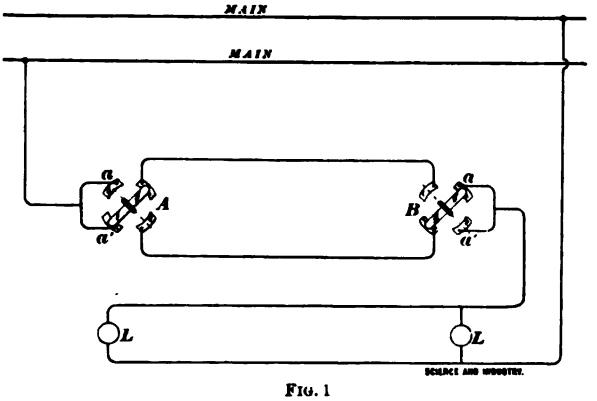

FIG. 1

It is often very convenient to control a light or number of lights from two different points, i. e., to have the wiring so managed that the lights may be turned off and on from either station, regardless of the position of the switch at the other station. In order to do this it is necessary to have two three-point switches connected as shown in Fig. 1. No attempt is made to show the actual construction of the switches, as every manufacturer has his own style of switch. In appearance they are much the same as an ordinary snap switch, the internal arrangement being slightly different. Usually, there are four contact pieces, but two of these are connected, thus making in reality a three-point switch. With the aid of the diagram, the connections can readily be traced out for any particular make of switch that one may be called on to install. By tracing out the connections it will be seen that the light may be controlled from either station, regardless of the position of the switch at the other station. It will also be noticed that on and off positions of either switch will depend on the position the other switch happens to be in at the time.

Fig. 3 shows a somewhat similar arrangement of switches for controlling a light from three different stations. In this case it is necessary to use two three-point switches *A* and *C*, with one four-point switch *B*. In one position of the four-point switch, points *1* and *2*,

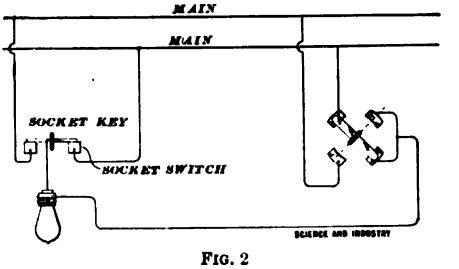

FIG. 2

and *3* and *4* are connected together as shown by the full lines. In the other position, the former connections are broken and points *1* and *3*, and *2* and *4* are connected together

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as shown by the dotted lines. By tracing out the connections it will be seen that the light may be turned on and off from any one of the stations, regardless of the positions of the switches at the other two stations.

Both the preceding arrangements are used most widely in hallways where it is desirable

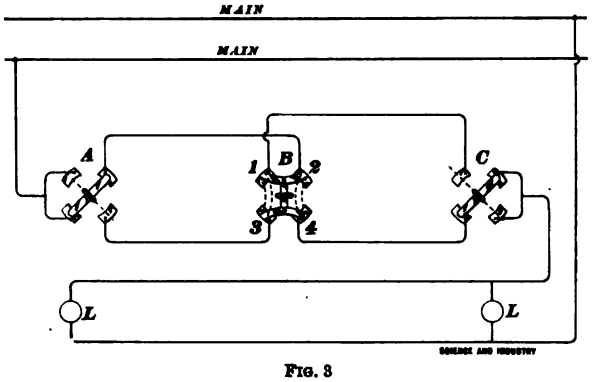

FIG. 3

to have the hall lights so arranged that they can be turned off and on from any floor. The plan shown in Fig. 3 may be extended to any number of stations by adding another four-point switch for each intermediate station.

Another switching device that has recently been brought out is the three-way lamp socket. This is a key socket arranged with contacts so as to practically take the place of a three-point switch, and, by using a socket of this kind in connection with a three-point wall switch, the light may be turned on and off either at the socket or at the wall switch. With lamps wired up in the ordinary way, with a side switch and ordinary key socket, one often finds that, on entering a dark room and attempting to turn on the light at the switch, some one has left the lamp turned off at the socket. He is then obliged to grope his way in the dark over to the center of the room, and in so doing probably comes up against more chairs and tables than he can ever remember of seeing there in daylight. When he reaches the lamp he will very likely find that in his various twistings of the wall switch he has left the current off, and has to go back again to turn it on. This may seem a rather exaggerated case, but it frequently happens, nevertheless. With such an arrangement it is much better to have the center lights equipped with keyless sockets. Fig. 2 shows how the three-point wall switch and three-point socket may be connected up. Fig. 4 shows another method. The most convenient method to use in any given case will depend on the arrangement of the house wiring. By using the three-point socket, one three-point switch is dispensed with, and the wiring is considerably simplified. In both Figs. 2 and 4 the positions of the switches are such that the lamp is out. If

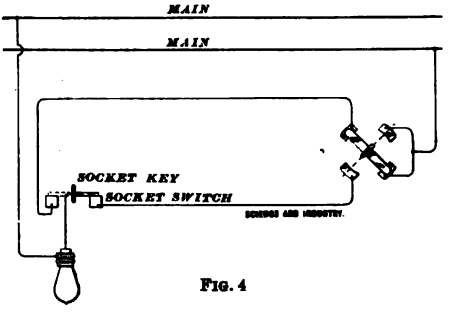

FIG. 4

either the socket switch or the wall switch is thrown to the dotted position, the lamp will light up.

TO IMPROVE FURNACE EFFICIENCY

IF THE tin hot-air pipes of a furnace are not covered with insulating material, and do not heat the rooms properly, the efficiency may be considerably improved by covering the pipes with asbestos paper. This will prevent loss of heat by radiation through the pipes. The asbestos may be put on neatly and strongly by first soaking it in water, and then winding it spirally around the pipes, allowing each layer to lap about two inches over the other. Use a brush to smooth it down so that no air spaces will remain between the asbestos and the pipe. A good fire should be kept burning in the furnace when the pipes are being covered, as the moisture will thus be evaporated from the asbestos before it has had time to corrode the pipes. When the covering is put on in this way it will shrink and stick to the pipe as though pasted on.

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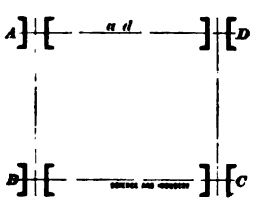
USEFUL IDEAS

MARKING STRUCTURAL STEEL FOR ERECTION

Emil Kurtz, Milwaukee, Wis.

Do DESIGNERS of structural-steel buildings follow any particular system of marking the different members, so that during erection it can readily be seen which girder or column the member connects or in which horizontal plane it belongs? I wish some one would say something on this subject in a subsequent issue of your magazine.



It is my business to make out lists of field rivets and bolts for structural work. The details do not state the connections of the different members, and the erection plan often contains all the members in three or four different horizontal plans, making it very difficult to ascertain whether a member belongs at the top, bottom, or middle of a column, or whether it connects to another horizontal member. I sometimes find it necessary to hunt up the details for six or seven members before I can find the one I want.

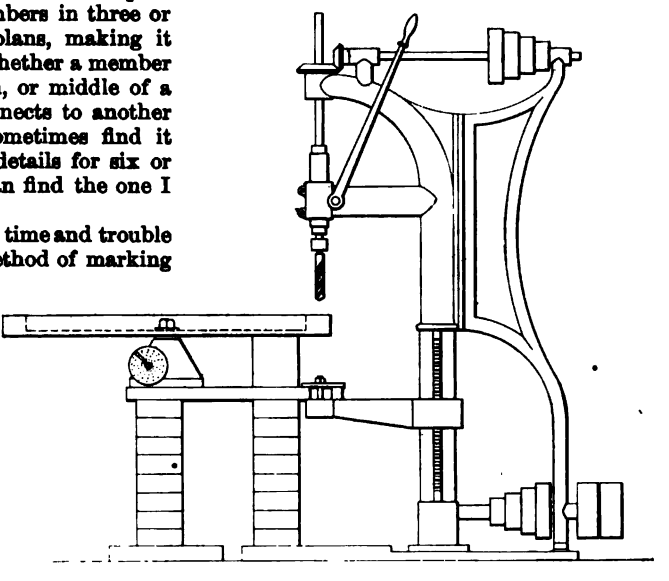
It seems to me that much time and trouble could be saved by some method of marking that would indicate the position of the member, and its elevation above the ground. For instance, in the accompanying sketch, *A*, *B*, *C*, and *D* are columns, all vertical members being designated by a capital letter. The location of the columns in a horizontal plane can be indicated by affixing to the capital letter a numeral that will show to what tier the column belongs. Thus, *A 1* would indicate the basement column at the location of *A* on the plan, and *A 2* would indicate the column directly above *A 1*. The horizontal members connecting two columns could be reasonably marked with the same letters as the columns connected, but using the small letters instead of the capitals. Thus, the member connecting the basement columns *A* and *D* would be marked *a d 1*, *a* being nearest to the end that connects to column *A*, and *d* being nearest to the end joining column *D*.

This method is only a suggestion, and the experience of others along the same line would be of great interest to me.

CUTTING A LARGE INDEX PLATE

J. C. J., Canada

WE HAD a large index plate to be cut, about 5½ feet in diameter, with 192 teeth. Of course, our milling machine was too small for such large work, so we laid it off on the upright drill. First, we took the table off the drill press, and built it up with planks some feet away, as shown in sketch. We



next took our milling-machine head and placed it on the table; and on the head placed the index plate on an arbor, and tightened the nut firmly, so that there would be no backlash or slip while indexing it around. Next, we drilled as many holes as there were teeth to go in the plate, with a

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drill large enough to give us the right radius of the bottom, or base, of the tooth. The 192 holes being drilled, we took the plate out of the drill press and cut the teeth with a cold chisel and file; this made a very neat job.

A SIMPLE SCHEME FOR BENDING IRON CONDUITS

C. E. Nicholas, Columbus, Ohio

IN FIREPROOF buildings, iron and steel conduits must be used throughout for the electric

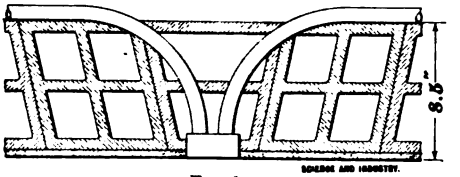

FIG. 1

wiring, and these conduits have to be bent to suit their location. The arrangement shown below has been found simple and convenient for making these bends. In work of this kind it is always advisable to avoid joints and elbows wherever possible, as the fewer of these, the easier it is to draw in the wire. In order to make a bending form, it is first necessary to determine the thickness of the arch at the outlet, together with the thickness of the plaster, and from these deduct the thickness of the outlet box as shown in Fig. 1. This will leave 7 inches for the radius of the curve.

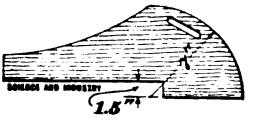

FIG. 2

Next select a good piece of 2-inch plank, about 18 inches long and 10 inches wide. Lay out the curve on one end and slope back the other as shown in Fig. 2; a slot may be

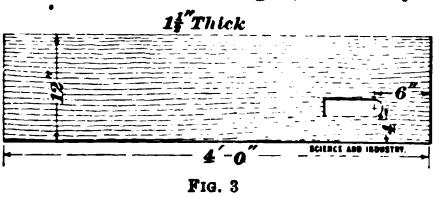

FIG. 3

cut in the piece as shown, to serve as a handhole for carrying the form about the building. A groove should be cut in the curved edge, to prevent the pipe from slipping off sideways. Procure another piece of plank, 4 feet long by 12 inches wide, and cut a slot in it as shown in Fig. 3. Fit the piece shown in Fig. 2 into it, leaving a hole in the base for the pipe to pass through, and make sure that it is not more than 7 inches from the bottom of the form to the top of the curve. After

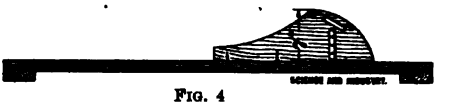

FIG. 4

this piece has been fitted it may be securely fastened from the bottom by means of lag-screws, as shown in Fig. 4. Two ⅞-inch pieces should be fastened across the bottom, as shown, to keep the plank from warping, also to allow an additional length of pipe to make up for shrinkage in bending, as well as space for the locknuts used to hold the outlet box in place.

This form was first used for bending insulated conduits, such as the interior and the armorite. With such conduits, a cable the size of the opening in the pipe should be inserted to make the inside tube hold its shape. Each end of the cable, which should be about 12 feet long, is first reduced in size by cutting away the inside layers,

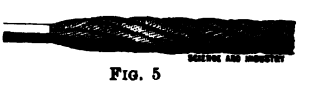

FIG. 5

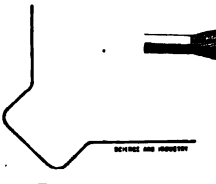

FIG. 6

closing the outer ones down over them, and wrapping with another wire or slipping a short tube over them, and soldering as in Fig. 5. It is not necessary to use this cable when bending plain uninsulated conduits. By using this method, wires have been run around four bends, as shown in Fig. 6, without any trouble.

A NOVEL BLUEPRINT FRAME

E. Percy Lea, Mexico City, Mexico

IN THE columns of a recent issue of your magazine I noticed an article describing a blueprint frame, which, though easily made, is not as simple as the one in use here. The frame I wish to describe consists of a large sheet of pasteboard about ⅛ inch in thickness. On this is secured, by the ends only, the tracing to be copied. When ready for printing, the frame is bent concave, thus loosening the tracing and allowing room to slide the sensitized paper under the tracing. The frame is then bent convex, and the tracing thereby drawn tight all over, and, being held by notched sticks, is ready for exposure. In using this frame, it is well to turn it around two or three times while printing,

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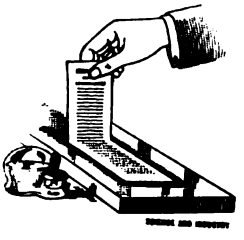
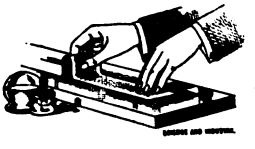
to get an even distribution of sunlight on the bent surface. This frame is worked successfully with prints as large as 3 feet by 4 feet, and gives clear lines in the smallest details. The cost of one of these frames is, approximately, 50 cents. They can be bought anywhere, and are ready for use without preparation or delay.

GOOD PASTE FOR CLIPPINGS

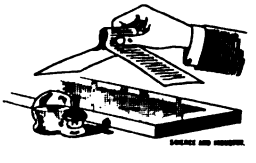
C. S. W., Long Island City, N. Y.

I READ with much interest the article by "Spacer," entitled "Scrapbooks," in SCIENCE AND INDUSTRY, November, 1899, and have a suggestion to make along the same lines. In pasting clippings, I have used very successfully an adhesive material consisting of ordinary laundry starch, prepared as follows: Moisten with cold water one tablespoonful of starch until it falls, then stir it into a good-sized cup of boiling water until it is thoroughly mixed; when cool, the mixture is ready for use, and may be applied with a sponge. The advantage of this preparation is that it is colorless, and the chance of soiling the sheet of clippings is avoided; the cost of the mixture is inconsiderable.





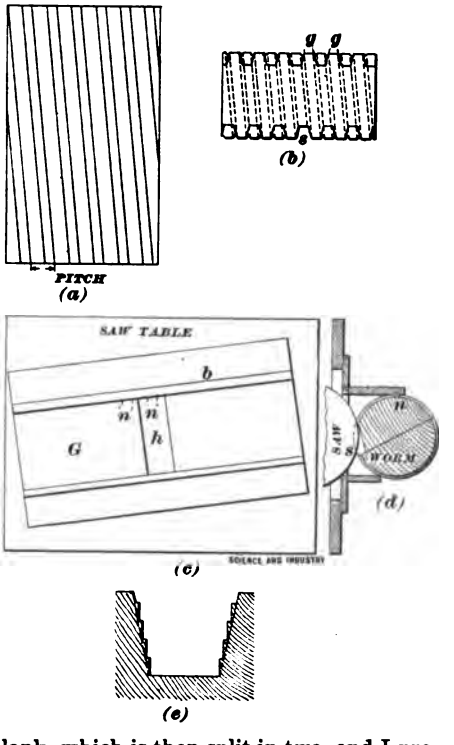
I might further add that, while on a recent visit to New York, I stepped into a detective's office, where, as you undoubtedly know, newspaper clippings constitute a large part of the stock in trade. I found that the boy that attends to visitors was engaged in a "pasting bee." He was using ordinary mucilage, which he spread on a glass slab with a brush; taking the clipping, he pressed half of it on the glutinous surface and, adroitly doubling and raising the back of the clipping, he succeeded in transferring it from the slab to the scrapbook. The operation can best be understood by referring to the accompanying sketches. This struck me as a good idea and of value to those that have a great deal of such work to do, for by this method the mucilage is thinly and evenly spread, and the work is done both rapidly and well.



MAKING WORM-PATTERNS

Baltimore

AS A USEFUL idea I offer the following description of my method of making worm-patterns with very little trouble and about half the usual cost. I first turn up a blank equal in diameter to the outside diameter of the worm, the blank being parted in the middle, of course. Next, on a piece of paper of a length equal to the circumference of the blank, I lay off the pitch and width of the top of the worm-thread, as shown in (*a*). This piece of paper I glue around the



blank, which is then split in two, and I proceed as follows: I lay out the shape of the thread on one half only, and cut out one space [see *s* (*b*)]; then I cut two grooves around the whole pattern, along the lines on the paper, about $\frac{1}{8}$ inch deep, as shown at *g*, in (*b*). Next, I make a guide *G*, shown at (*c*), consisting of a box with a back *b* and a square hole *h* in the bottom, to lay the pattern in. Into the back *b* I drive four nails

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n and file their heads flat; these nails are spaced so they will fit the grooves g, g in the blank and serve as guides; so that, if the blank is placed in the box and turned, it will be screwed past the opening h in the box. The whole arrangement is now ready to be placed on the saw table, with the saw at the same angle as the lead of the thread. The saw is next raised to project about $\frac{1}{8}$ inch into the space s cut out of one half of the pattern [see (d)], the box being clamped to the table, and the saw started. When the worm-pattern is turned in its guide, the saw will cut a groove $\frac{1}{8}$ inch deep around it on one side of the thread; by reversing the worm and turning back, the other side will be grooved. Next, the box is moved a little, so that the saw will come nearer the center of the space, and the saw raised another $\frac{1}{8}$ inch. The operation of grooving is then repeated until the depth of the thread is reached. By careful handling, one can saw within $\frac{1}{32}$ inch of the thread. After the latter is gouged out in this manner, and has a sectional appearance like that shown at (e), it is smoothed down with a chisel and finished.

VENEER CUTTING

Editor

A CORRESPONDENT writes in for a method of computing the length of veneer that can be cut from a 17-inch log with a 7½-inch core

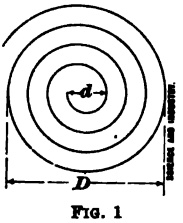

FIG. 1

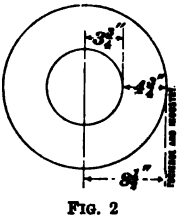

FIG. 2

of unsound wood, the veneer being $\frac{1}{10}$ inch thick.

As veneers are cut from the log by means of a knife, and cause no waste in sawdust or shavings, the problem resolves itself into finding the length of a spiral with its coils $\frac{1}{10}$ inch apart. A convenient formula for this purpose, where n equals the number of turns of the spiral, is as follows:

$$\text{Length} = \pi n \left(\frac{D+d}{2}\right).$$

In the case under consideration, D equals 17 inches, and d, 7½ inches. The thickness of wood available on each side of the log equals 4¼ inches, and, with the veneer $\frac{1}{10}$ inch thick, will allow $20 \times 4\frac{1}{4} = 95$ turns; n, therefore, equals 95.

Substituting values in the above formula, length =

$$3.1416 \times 95 \left(\frac{17+7\frac{1}{2}}{2}\right) = 3{,}656.01 \text{ inches};$$

3,656.01 inches equals 304.67 feet, the length of the veneer that can be cut from the log.

HOW TO CLEAN TRACINGS

C. T., Ohio

TRACINGS that have been subjected to considerable use become greasy and full of spots. It is, of course, desirable to keep them neat, but in shops, especially, this is almost impossible, unless they are cleaned now and then. It has often surprised me to find tracings in drafting rooms so full of dirt that it has been impossible to tell some of the measurements and lines on them. They certainly do not print well in such a condition. To clean them, try this method, and you will be surprised to find how quick and well it can be done:

Place your tracing on a blotting paper right side up. Then rub it briskly with a clean rag dipped in gasoline, or, still better, benzine. Pencil marks, grease, and dirt will soon change place, the blotter taking up a great deal, and the rag the rest. When, as is often the case, an order is in a hurry, a draftsman has to make a sketch or drawing on tracing cloth without first making an original drawing on paper, it is thus very handy to be able to quickly take out pencil marks and spots, after having inked in, using, of course, waterproof ink.

A CRITICISM ON BENDING PIPE FOR STAIR RAILING

J. G., Brooklyn, N. Y.

I NOTE with interest the article on bending iron pipe for stair railing, in the Chips and Spalls columns of the December issue. I cannot, however, agree with Mr. Brown as to the efficiency of the method he suggests. I am connected with a large architectural iron works in this city, and two of our best foremen confirm my opinion that it is not as good as some other devices known to us.

In the first place, I understand that the pins are arranged around the outside of the curved iron bar. As circular stairs vary in diameter and pitch, the bar or tool would only approximately correspond to the curve of any stair, and even if the pipe were bent and pinned tightly to the bar, it would certainly spring back again to some degree when released. But suppose that the tool were perfectly satisfactory for one size of stair;

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it would only enable the operator to get somewhere near the curve of any other size of stair, and I think that the difficulty of adjusting it to the exact conditions, after having got it as near as possible by the aid of the tool, would require about as much work as bending the pipe from its original straight condition. Possibly your correspondent is able to explain exactly how he would proceed if the diameter of the stair were smaller than the curve of the bar.

I send a sketch and description of what we consider the best and simplest method when rollers and steam power are not available. Make a templet about 3 feet long of any light iron, adjusting it to the proper shape by trying it against the outside edge of the stair, which we assume is already made. The only tool necessary is a stout block of wood with a slot cut in one side. The block can be sunk in the floor or bolted in any way that will make it sufficiently firm. The accompanying figure shows clearly the idea. The slot is about 2 feet from the ground, and the pipe is put in the slot, bent gradually, advanced a few inches at a time, and is also given a slight turn or twist. One man can do the bending, while another holds the templet against the pipe in order to see that the right bend and turn is given it.

In doing the bending the free end of the pipe is raised, though, if it is considered preferable, the slot may be from 6 to 7 feet above the floor, and, in that case, the pull on the pipe would be downward. The essential points are that the pipe shall always be bent

and turned to follow the shape of the templet. If considerable pipe is to be bent, the jaws of the slot should be lined with iron, to make them wear longer; if the size of the pipes varies, it is not a difficult matter to make the slot wide or narrow by means of a screw or any similar device.

EDITORIAL COMMENT

THE STANTON HEATER

THE Stanton Heater Company, Martin's Ferry, Ohio, are now installed in their new factory. They are making the Stanton heater, which is a warm-air furnace of merit and of an entirely novel pattern. It is especially desirable in places where the basement is low, as it is only 69 inches high from the floor to the uppermost point in the heater. The heater is also arranged as a combined hot-water and hot-air heater, when desired. A descriptive catalogue, fully illustrated, will be mailed free to any one writing for it to the address above given.

THE STANDARD TOOL COMPANY

THE 1900 edition of the catalogue of the Standard Tool Company, Cleveland, Ohio, is at hand. The catalogue contains a full list of all the various productions of this company, as straight and taper-shank twist drills, millimeter sizes of twist drills, combined drills and countersinks, bit-stock drills, twist drills for woodworkers, spoon bits, screwdriver bits, oil-tube drills, taper sockets, twist-drill gauges, mandrels, reamers of various kinds, all kinds of taps, drill chucks, end mills, milling cutters, etc. The catalogue is standard size, 6 in. × 9 in.

METAL CEILINGS

WE ARE in receipt of the booklet of the Berger Manufacturing Company, of Canton, Ohio, showing some of their classified designs of metal ceilings. These designs embrace such styles as Greek, Roman, Romanesque, Gothic, Moorish, Italian and German Renaissance, Rococo, Empire, and Colonial. Among the ceilings illustrated are some particularly suitable for churches, synagogues, hospitals, libraries, schools, and dwellings, and others for hotels, auditoriums, etc. The Berger Company will be pleased to render assistance to any one wishing to select a ceiling suitable for any purpose.

UNIVERSITY OF TENNESSEE RECORD

WE HAVE received a copy of the current number of the "University of Tennessee Record," published by the University of Tennessee, Knoxville, Tenn., containing several articles of interest on a variety of topics. The leading article is by J. R. McColl, and gives a description of

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the electric transmission of power as applied to the shops of the University of Tennessee. Other articles contained in the number are "An Electric Recording River Gauge," by W. M. Fulton; "Commercial Analysis of Soaps," by J. O. LaBach; besides a number of shorter articles.

OFFICE DESKS

We have received the latest catalogue of the Philadelphia Desk Company, manufacturers of office desks. This catalogue contains illustrations of some new designs, among which we notice several roll-top typewriter desks that the manufacturers claim are superior to anything of the kind heretofore placed on the market. They are so arranged that two persons can use one at the same time, one operating the typewriter and the other using the writing surface; while at the same time this arrangement gives the conveniences of two desks in one to a person having use for a roll-top desk and a typewriter. If you are in want of an office desk of any kind, address the Philadelphia Desk Company, box 4453, Philadelphia, Pa., and they will be pleased to send full descriptions and quote prices.

CARD CATALOGUE

Mr. George S. Comstock, Mechanicsburg, Pa., has sent us a number of cards, regular library-card size and properly perforated, for our card index. Each card contains a specialty he is building, or prepared to furnish, among which we note sawmills, ore- and coal-washing machinery, blacksmiths' tools, wine presses, feed-cutters, fodder crushers, etc. While the idea of printing a short synopsis of goods in library-card form is not a new one, it is an idea we would like to see more generally adopted, as a properly kept-up card index of manufactured and other products is one of the most convenient and time-saving devices.

THE "JOHNSTON" GAS ENGINE

Many amateurs and practical machinists build small engines, either to gratify their interest in mechanics, or, by the exercise of their skill, to provide themselves with a motor at a small expense. The practical experience so obtained has doubtless done much to develop the engineers and mechanics who have been the means of placing this country in the van of the world's designers and builders of machinery.

Recent developments in gas engines have aroused in amateurs an interest in this branch of engine building, and created a demand for designs and castings for small motors of this type. To meet this demand, Mr. George H. Johnston, of Sparrows Point, Md., has designed the "Johnston" gas engine, for which he is prepared to furnish complete working drawings, together with a description that will enable any one having the requisite skill in the use of tools to provide himself with a well-designed engine. The set comprises complete working drawings of every detail of a $3'' \times 3''$ gas or gasoline engine of the two-cycle type, including a carbureter for supplying the gasoline vapor, and modifications for the application of the engine to either stationary or marine work. In addition to the drawings for the $3'' \times 3''$ engine Mr. Johnston is prepared to furnish drawings for engines rated at $2\frac{1}{2}$, 4, and 6 horsepower, also of vaporizers, carbureters, and reversible propellers. He is also preparing to furnish castings for the engine to those that do not care to make them.

BOOK NOTICES

How to Run Engines and Boilers. By Egbert P. Watson. Published by Spon & Chamberlain, New York. Price, $1.00.

This is the fourth edition of this well-known book, revised and enlarged by the author. Its value has been enhanced by adding a chapter on water-tube boilers, in which the principal types are treated of.

Formulas and Tables. By J. H. Kinealy, professor of mechanical engineering, Washington University, St. Louis, Mo. Price, $1.00.

This is an exceedingly neat, compact, and apparently well-compiled and edited 50-page handbook for heating engineers, architects, contractors, and others interested in heating and ventilation for buildings. It is a translation of German formulas and tables that were published in serial form in "The Metal Worker," especially prepared for those that plan or erect heating apparatus. The proper use of the various formulas and tables contained in this little book will enable any one to determine the heat lost through any of the various kinds of walls that may enter into the construction of a building. The formulas appear quite simple and easy to apply. English units are used instead of German. The translation directs our attention to the vast amount of good work that has been done in recent years by German engineers in heating and ventilation.

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ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

1. Put this address both on the envelope and at the head of the letter.

2. Only questions of general interest to our readers will be answered.

3. No questions will be answered by mail.

4. Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.

5. The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.

6. Reference to inquiries previously answered should give date of issue and number of question.

7. Questions cannot be answered in the issue of the month immediately following their receipt.

8. Any book not out of print and for sale by regular dealers may be ordered through the magazine.

9. We will not undertake to calculate windings of dynamos and motors, as this involves considerable work and is seldom justified.

EDITOR'S NOTE.—F. H. P., Pittsfield, Mass., calls our attention to a numerical error in connection with question 115 of the March issue. The error was caused by not squaring the negative quantity under the radical, and the result should have been 34.2 sq. ft. instead of as printed. Our correspondent inquires if the formula is general, and asks us to apply it to a triangle whose sides are 3, 26, and 25, letting a, b, and c be 26, 25, and 3, respectively, in one case, and 3, 26, and 25 in another case. The formula is perfectly general, no matter which values are assigned to the different letters. Thus, for the first case,

$$\frac{b}{2}\sqrt{a^2-\left(\frac{a^2+b^2-c^2}{2b}\right)^2} =$$

$$\frac{26}{2}\sqrt{3^2-\left(\frac{3^2+26^2-25^2}{2\times 26}\right)^2} = 13\sqrt{3^2-\left(\frac{60}{2\times 26}\right)^2} =$$

$$13\sqrt{3^2-\frac{30^2}{26^2}} = \frac{13}{26}\sqrt{3^2\times 26^2-30^2} =$$

$$\tfrac{1}{2}\sqrt{5,184} = 36 \text{ sq. units.}$$

For the second case,

$$\frac{25}{2}\sqrt{26^2-\left(\frac{26^2+25^2-3^2}{2\times 25}\right)^2} = 36 \text{ sq. units.}$$

***

In regard to question 43 (c), Answers to Inquiries, February, 1900, Mr. L. M. R., Vinton, Iowa, sends the following: If T. J. A., Boston, Mass., will block up one of his wall controllers to about full load, or far enough to make one machine take a little more than half the load, letting the other controller do all the regulating, he will have less trouble with his T. H. machines hunting when in series.

***

(130) What is the best method of constructing dancing floors? Is a double tier of joists required?

P. B., Chicago, Ill.

ANS.—The vibrations on a dancing floor are severe, and unless special provision is made, the plaster ceiling beneath is apt to crack. In constructing such a floor, it is usual to support the ceiling entirely on other joists than those that carry the floor. The joists supporting the ceiling can be placed between the floor joists, and, in every case, must not be in contact with or attached to them in any way.

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(131) (*a*) What is the temperature of fusion, the temperature of vaporization, the latent heat of fusion, and the latent heat of vaporization of carbonic-acid gas and ammonia gas, as used in refrigerating plants? (*b*) How do you find the number and strength of staybolts for boilers?

G. J. S., Kansas City, Mo.

ANS.—(*a*) As neither carbonic-acid gas nor ammonia gas ever appear in the solid state in practical refrigerating plants, it is not necessary to know either the temperature or the latent heat of fusion. The temperature and latent heat of vaporization differ with the pressure. Under a pressure of 1 atmosphere, the temperature of vaporization of ammonia is about 30° F. below zero; and the latent heat of vaporization is 574 B. T. U. The temperature of vaporization of carbonic-acid gas, under a pressure of 1 atmosphere, is about 124° F. below zero. At 0° F., and under a pressure of 310 lb. per sq. in., the latent heat of vaporization of carbonic-acid gas is 128.2 B. T. U. Ammonia, at the same temperature, and under a pressure of 30 lb. per sq. in., has a latent heat of 555.5 B. T. U. Different authorities vary somewhat in reference to the above values. Those given here are the values given by a well-known authority in this country. (*b*) Various rules and methods are used by different builders and boiler inspectors for finding the number and dimensions of staybolts. The following rules are those prescribed by the United States Board of Supervising Inspectors of Steam Vessels: The pitch of the stays supporting the fireboxes, furnace, and back connections must in no case exceed 10½ in., nor be more than will be determined by the following rule, the thickness of the plate and the steam pressure being given. To find the pitch of staybolts, multiply the constant 112 by the square of the number of sixteenths of an inch in the thickness of the plate. Divide this product by the steam pressure, and extract the square root of the quotient. For plates exceeding $\frac{7}{16}$ in. in thickness, substitute the constant 120 for 112. Having the pitch, the total number of staybolts is easily found by dividing the area to be supported by the square of the pitch. The total stress in each stay is found by multiplying the area that it supports by the steam pressure. Thus, if the pitch is 6 in., the area supported is $6 \times 6 = 36$ sq. in.; this area multiplied by the steam pressure will give the stress on the stay in pounds. The net area of the stay is found by dividing the total stress, as found above, by the allowable unit stress. The values for the allowable unit stress prescribed by the above board are as follows: The maximum stress on a wrought-iron brace or stay of any size, or a steel stay up to 1¼ in. in diameter at the smallest part, is fixed at 6,000 lb. per sq. in. of cross-section of the stay or brace. Steel staybolts exceeding a diameter of 1¼ in. at the smallest part, and not over 2½ in. in diameter, may be allowed a stress not exceeding 8,000 lb. per sq. in. of section. Steel stays above 2½ in. in diameter may be allowed a stress not to exceed 9,000 lb. per sq. in. of cross-section.

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(132) (*a*) What is the cost of a 330-watt dynamo? (*b*) How long will it take a dynamo of this size to charge a storage battery used to supply current for three 16 c. p. 55-volt lamps in circuit for 3 hours? (*c*) Will a storage battery lose part of its charge in 12 hours; if so, how much? (*d*) Where can such a storage battery be obtained or information be found in regard to its construction?

A. H. L., Rugby, Ont., Can.

ANS.—(*a*) A 330-watt 55-volt dynamo will probably cost between $30 and $40. (*b*) Charging at the rate of 3 amperes, it should take about 4 hours. (*c*) An open-circuit battery should lose very little of its charge in 12 hours, if care is taken that there are no leaks on the circuit. (*d*) Electric Storage Battery Co., Philadelphia, Pa. An article on the manufacture of small storage cells, now in course of preparation, will be published in SCIENCE AND INDUSTRY in the near future.

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(133) Kindly mention several good periodicals, either monthly or weekly, pertaining to carpentry, wood working, etc. L. J. B., Bradford, Mass.

ANS.—"Carpentry and Building," 232 William St., New York; "Architects' and Builders' Magazine," 28 Warren St., New York; and "The Wood Worker," Indianapolis, Ind., a journal for machine wood workers. They are all monthly magazines, and the price of each is $1 per year in advance.

***

(134) (*a*) How many levers has a locomotive engineer to attend to, and what are their names? (*b*) How often does a locomotive require oiling? (*c*) How often does a locomotive take in water?

A. H. S. B., Big Glace Bay, Nova Scotia.

ANS.—(*a*) Throttle lever, reversing lever, whistle lever, injector lever, cylinder-cock lever, sand lever, and safety-valve lever. Also, if pumps are used, there are levers for the petcock and the feed-valve (sometimes called the *lazy cock*). Certain other appliances are in use, generally worked by wheel handles; they are the blower, lubricator, and sand blast. Besides the above, the fireman has certain details to attend to. (*b*) With the improved oil cups now in use on most roads, the engine can run from 80 to 100 miles between oilings. (*c*) It depends on the train hauled, the nature of the road, and the weather; also on the capacity of the tank. A heavy freight train will take water about every 20 miles, and a passenger train about every 50 miles.

***

(135) (*a*) In plastering houses in the late fall or winter, I find spots that we call *cold spots* and some call *quagmires*. Can you tell me what is the cause of this? (*b*) I plastered a house last November, and three months later the painter tinted the walls a pinkish hue, but, strange to say, in the morning following the day on which the color was applied, it was found to have disappeared. Can you account for this? (*c*) What colors, when placed in lime, will not be affected by it? (*d*) What preparation would you advise for finishing hardwood floors so that they will remain bright with wear?

"MACBETH," Fredericton, N. B.

ANS.—(*a*) Probably one of two causes: the lime might not have been thoroughly slacked, or freezing might have taken place directly after plastering. If the lime were not thoroughly slacked, and applied to the wall, it would be likely to slack on the wall. This causes blisters and forces pieces of plaster from the surface. The freezing would cause spots having the appearance of mushrooms, and these would more than likely remain soft. (*b*) Pink is one of the most delicate colors, and we are not surprised that it disappeared. Even 3 months is not long enough in the winter for plaster to dry thoroughly, and it is more than likely that it was still green and absorbed the color. We have seen plaster that, when put on the wall, generated heat for a considerable time, and in this state it absorbed moisture rapidly; color placed on it while in this condition will be absorbed throughout its body. (*c*) Usually, in coloring plasters, preparations called *plaster colors* are used. These tint the plaster and avoid the annoyance so often seen with painted or tinted walls in which the scaling or peeling off of the paint shows the white plaster in disfiguring spots. All information regarding such colors can be obtained from the manufacturers, Toch Bros., 468 W. Broadway, New York, N. Y. (*d*) The best preparation to use is wax. For all information regarding wax floors and how to care for them, address Barron, Boyle & Co., Cincinnati, O.

***

(136) (*a*) Since one side of every subscriber's metallic circuit in a common-battery system is connected to the positive terminal of one storage battery, why is this not a common-return system? (*b*) Why should the lightning-arrester wires that are stapled to the pole and cross-arms, as mentioned by Poole, cause cross-talk? (*c*) Would transmission be as good with condensers, as in Fig. 2, as with repeating coils? (*d*) What would be the effect of connecting a condenser as in Fig. 1? (*e*) Why can I not charge a 2 M. F. condenser, that seems to be in good condition for telephone work, with a Wimshurst machine? (*f*) What is the approximate resistance of a solid back transmitter (when at rest) designed for a common-battery system? F. M. W., Latrobe, Pa.

ANS.—(*a*) A common-return system is generally understood to consist of one wire strung on the same poles as the telephone wires, for all of which it forms the return circuit. In a common-battery complete metallic circuit, each circuit is entirely separate until both sides have passed through all the telephone and switchboard apparatus. They are then joined by wires of very low resistance to the one battery. (*b*) Because the current from one wire can

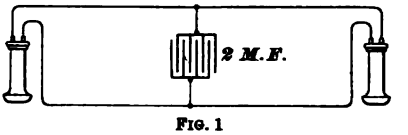

FIG. 1

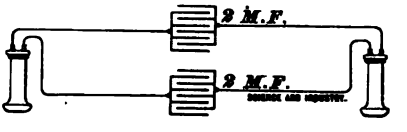

FIG. 2

leak (especially in wet weather and in case the ground connection of the lightning-arrester wire is bad) along the cross-arm to the arrester wire and then to another wire, even if the live wires do not touch the arrester wire. If this leakage is sufficient, cross-talk will follow. (*c*) Probably not, because there is already an excess of electrostatic capacity in the line wires, and you are making it worse by adding condensers. A repeating coil would add inductance, and the electrostatic capacity is not only not increased but the inductance tends to counteract the capacity. (*d*) A condenser connected as in Fig. 1 would shunt the talking current across, and reduce the current at the distant end. (*e*) You may have punctured the insulation with the Wimshurst machine. The insulation may be so low that the charge from the machine leaks away before you can observe any discharge, but at the same time the insulation may be good enough for telephone work, because the frequency is then so great that it charges and discharges before much of the charge can leak from one plate to another. (*f*) About 15 ohms.

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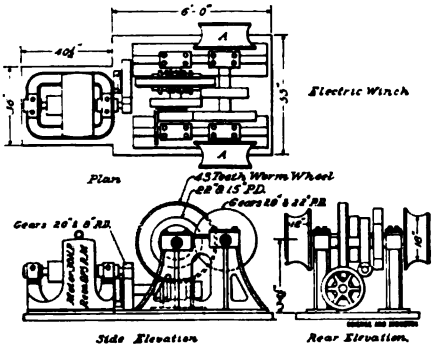
(137) In the case of the electric winch shown in the accompanying sketch, what power and speed is developed on the winding drums *A*, *A*, and how are the results reached? W. S. S., Ottawa, Can.

ANS.—The first thing that must be determined before the above calculations can be made, is the efficiency of the hoisting mechanism; in other words,



what percentage of the total power developed by the motor is actually utilized at the winding drums. It will be hard to give accurate figures for this, because the efficiency may vary widely, depending on the condition of the gears, etc. In order to be on the safe side, we will take the efficiency at 50%, as this should be a fair average. We will then have $30 \times .5 = 15$ H. P. at the winding drums. If the motor makes 975 R. P. M., the worm-shaft will make $\frac{975 \times 8}{20}$ R. P. M., and the worm-gear shaft will make $\frac{975 \times 8}{20 \times 43}$ R. P. M. In hoisting, the 15-inch gear will mesh with the 29-inch gear, so that the speed of the drum shaft will be $\frac{975 \times 8 \times 15}{20 \times 43 \times 29} = 4.7$ R. P. M. The drums are 18 in. in diameter, or about 4.7 ft. in circumference. Since we have 15 H. P. exerted at the drum, we must have $P \times 4.7 \times 4.7 = 33{,}000 \times 15$, where P is the total pull exerted at the drums. From this we get $P = 22{,}400$ lb., nearly, or 11,200 lb. on each drum. The winch would then be capable of lifting 22,400 lb. at a speed of $4.7 \times 4.7 = 22.09$ ft. per minute.

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(138) (*a*) Having an 18″ water pipe 230 ft. long, with five 45° elbows and four 90° elbows discharging from one tank to another under a 14½′ head, what will be the velocity of flow and the quantity of water discharged? The elbows are all of rather small radius (about standard). (*b*) With same distance and head, what would be the rate of flow and quantity discharged through a straight pipe? (*c*) Please give the method of solving the above.

R. S. P., Pittsburg, Pa.

ANS.—(*a*) With a smooth cast-iron pipe, the velocity of flow would be nearly 12 ft. per sec., corresponding to a discharge of about 21 cu. ft. per sec. (*b*) The velocity of flow would be about 15½ ft. per sec., corresponding to a discharge of 27.38 cu. ft. per sec. (*c*) The above results were obtained by an application of the formula

$$v = 8.02\sqrt{\frac{h}{1 + f\frac{l}{d} + m + nc}},$$

in which v = velocity of flow in feet per second; h = head in feet; f = a coefficient depending on the size and condition of the pipe and the velocity of flow; l = length of the pipe in feet; d = diameter of the pipe in feet; m = a coefficient depending on the form of the inlet end of the pipe and its relation to the reservoir; n = number of bends; and c = a coefficient depending on the relation between the diameter of the pipe and the radius of the bends. The values of the various coefficients used were taken from tables giving the results of experiments. It is possible the actual conditions under which your pipe operates vary considerably from the conditions under which the coefficients were determined. In such a case, the actual discharge of the pipe would be different from the calculated results.

***

(139) (*a*) What books costing not over $10 would you recommend for one desiring an elementary knowledge of mechanics? I understand mathematics through trigonometry, and have studied physics. (*b*) Under the same conditions, what would you recommend as good works for study in electricity, and where can I get them? I am familiar with the principles of the subject, and want to do some work on the technical side of it.

I. E. G., Pierre, S. D.

ANS.—(*a*) For works on mechanics, we can recommend the following: "Parkinson's Elementary Mechanics," price, $2.25; "Garnett's Elementary Dynamics," price, $1.50; "Hicks' Elementary Dynamics," price, $1.60; "Jessop's Elementary Applied Mathematics," price, $1.25. "Parkinson's Elementary Mechanics" would be the best to begin with. (*b*) For works on electricity we can recommend: "Elementary Lessons in Electricity and Magnetism," by Silvanus P. Thompson, price, $1.40; "Dynamo-Electric Machinery," by Silvanus P. Thompson, price, $6; "Electric Power Transmission," by Dr. Louis Bell, price, $2.50. You can obtain these books from The Technical Supply Co., Scranton, Pa.

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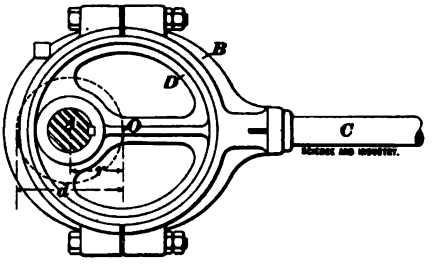
(140) In the accompanying sketch is shown an eccentric with its shaft *A*. (*a*) Please state what movement a valve would have if the eccentric were 2 in. in diameter. (*b*) Give the correct names of the different parts of the eccentric.

W. S., Weir City, Kan.

ANS.—(*a*) The distance the valve moves is not fixed by the diameter of the eccentric, but by the eccentricity, i. e., the distance r between the center



of the shaft and the center of the eccentric. A little consideration will show that the eccentric is equivalent to a crank in which the distance from the center of the shaft to the center of the eccentric is the same as the radius of the crank. For this reason, the distance r is sometimes called the *radius* of the eccentric. By observing the sketch we see that the center O of the eccentric moves around the center of the shaft in a circle whose diameter d is twice the distance r between the center of the crank and center of eccentric. It is also evident that the distance d, which is called the *throw* of the eccentric, is the distance moved by the valve, provided no rocker-arm is used between eccentric and valve, and that the throw will be the same for a given eccentricity r, no matter what the diameter of the

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eccentric may be. (*b*) The part *D* that revolves with the shaft is generally called the *sheave; B*, the *strap;* and *C*, the *eccentric rod.*

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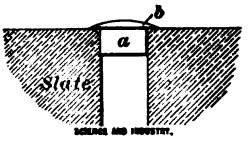
(141) (*a*) How can I find the contents of a cylinder in U. S. gallons? (*b*) How can I harden heads for turning machines? The heads are $\frac{3}{4}'' \times 2\frac{1}{2}''$, and have a $\frac{1}{2}''$ hole through them. I wish to obtain a method of hardening that will prevent them from cracking. E. W. McT., Steubenville, Ohio.

ANS.—(*a*) Multiply the diameter, in inches, by itself and by .7854. Multiply this product by the length of the cylinder, in inches. Divide the last product by 231. (*b*) We would advise you to heat the heads in molten lead kept at a red heat. Quench in a bath of lard oil, and keep them in the oil until cold.

***

(142) I have a switchboard made of slate, on which I have made a few changes in the placing of switches. This has left a few holes in the board. Can you show some method of plugging up these holes so as to give a good finish to the front of the board? W. H. M., Paterson, N. J.

ANS.—The following method is one used considerably by makers of switchboards, and it may answer in your case. The slate is always broken away more or less around the edge of the hole, so that it is a difficult matter to make a good finish by plugging with plaster of Paris and then finishing off with black enamel; this is, however, sometimes done. A very simple method is to turn up a number of plugs *a* of hard rubber. These plugs should enter the hole about $\frac{1}{4}$ inch, and may be stuck in with glue or simply made a tight fit. They should be provided with a flange *b* to cover the chipped-out portion around the hole; it also improves their appearance to have the top slightly convex, as shown. If the face of the plug is well polished, it matches the black enameled slate very closely.



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(143) (*a*) Will an accumulator of 300 ampere-hours capacity work an induction coil to good advantage? The coil is designed for a $\frac{1}{2}''$ spark. (*b*) What candlepower lamp will the accumulator light? (*c*) Will putting potassium bichromate into a cell that had 1 oz. less than the required amount—being used about an hour and then standing 10 days before the remaining portion is put in—affect the strength of the battery? If so, why?
J. K. F., Chewsville, Md.

ANS.—(*a*) Yes; an accumulator is usually quite satisfactory for the operation of an induction coil. The pressure used should be just high enough to work the coil without bad sparking at the contact maker. You should have an adjustable resistance in series with the primary, in order to adjust the current. (*b*) This depends on the number of cells you have at your disposal. A 16-candlepower lamp requires about 54 watts for its operation, or about $3\frac{1}{4}$ watts per candlepower. If you know the voltage of your battery and the current it can deliver, you can easily determine from the above the number of lamps it can operate. (*c*) The battery solution probably became deteriorated during the time that the batteries were standing idle. Chrome alum is apt to crystallize out in these cells after they have been set up for some time. These cells always work best when the solution is freshly mixed, and it is probable that your cells fell off in voltage simply because the solution was old, and not because of the lack of exact proportions in the electrolyte.

(144) How can I make a large simple bichromate-of-potash cell? E. C. S., Dorchester, Mass.

ANS.—Secure a glass or earthenware jar of the size required, and make a hardwood cover for it. Boil this cover in paraffin, or give it a good coat of asphaltum paint, to prevent it from absorbing moisture. Drill a circle of $\frac{1}{2}$-in. holes in the cover, so that they will come near the inside edge of the jar, and insert $\frac{1}{2}$-in. electric-light carbons in these holes, wedging them tightly, and allowing them to project above the cover about $1\frac{1}{2}$ in. These carbons should reach nearly to the bottom of the jar, and the upper ends should be electroplated with copper, so that a copper wire may be run around and soldered to the carbons, thus forming one terminal of the battery. A zinc plate about $\frac{3}{4}$ in. thick and 2 in. wide should be hung in the center of the cell, to form the other electrode; this zinc should be well amalgamated, and arranged so that it can be lifted out when the cell is not in use. The solution may be made up as follows: Sulphuric acid, 2 parts, is mixed with water, 4 parts, in one vessel; in another vessel, 1 part of potassium bichromate is dissolved in 8 parts of boiling water, and while hot is mixed with the first liquid prepared. All parts given above are by weight.

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(145) Can you recommend a good book on the foundry practice of brass and bronze alloys; also, on their chemical composition and microstructure?
M. J. M., Joliet, Ill.

ANS.—"The Practical Brass and Iron Founder's Guide," by James Larkin; price, $2.50. This book may be obtained from The Technical Supply Co., Scranton, Pa. We know of no book devoted to the chemical composition and microstructure of metals. Occasional articles on this subject have appeared in the technical papers; several contributions appear in the Transactions of the American Institute of Mining Engineers for 1898. "The Metallographist," published by A. Sauveur at 448 Tremont St., Boston, Mass., is devoted entirely to microscopic analysis of metals. You may find some articles on the microstructure of brass and bronze in its columns.

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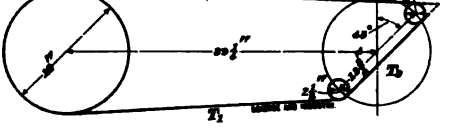
(146) Please explain a method of obtaining the length of the belt in the enclosed sketch.
C. E. H., Worcester, Mass.

ANS.—If d is the distance between the centers of two circles whose radii are r and r', respectively, the



length T of the direct common tangent to these two circles is given by the formula $T = \sqrt{d^2 - (r - r')^2}$. From this formula we get $T_1 = 34.07''$, $T_2 = 43.86''$, and $T_3 = 13.75''$. Evidently, the angle between the tangents T_2 and T_3 is less than 45°; hence, the arc of contact between the tangents T_2 and T_3 is a little less than $\frac{1}{8}$ of the circumference of the small pulley. In like manner, the arc of contact between T_2 and T_1 is a little less than $\frac{1}{4}$ of the circumference of the small pulley. By analytical geometry, the angle between the tangents T_1 and T_2 is found to lie between 5° and 6°. Therefore, the arc of contact of the belt on the big pulley is a little less than 186°, and the length of this arc is nearly $\frac{1}{2}\frac{1}{3}\frac{1}{3}$ of the circumference. The sum of these three arcs is 29.90"; which makes the whole length of the belt 121.58".

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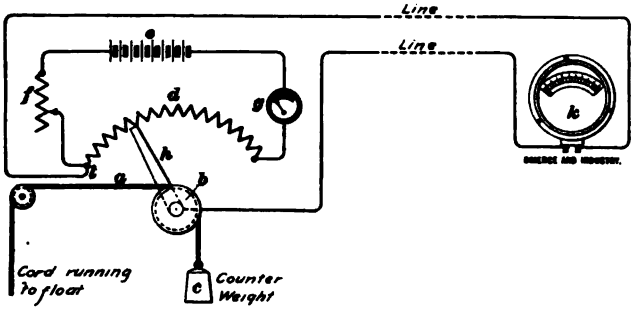
(147) What would you recommend as the most feasible scheme for recording on a gauge in my office every inch of variation in the level of a canal that is about 2,500 ft. distant? The variation of the canal is about 10 ft. The means of accomplishing this would be by electricity, and four line wires can be used if necessary. A. B. V., Joliet, Ill.

ANS.—We give an arrangement in the accompanying figure that might answer your purpose. The cord *a*, from a float, passes over the drum *b*; *c* is a counterweight used to keep the cord taut. An arm *h* is attached to the drum, so that it will move along the resistance *d* (about 200 ohms) when the float moves up or down; *e* is a battery consisting of 10 or



15 cells of some type that will be constant in its action and not greatly affected by changes of temperature. Cells of the Gordon or Edison-Lalande type will answer very well. These cells are connected to the terminals of *d*, and send a small current through it all the time. This current should be kept the same at all times, and should be checked up now and then by means of a small current indicator *g*. The current may be adjusted to its proper value by means of a small adjustable resistance *f* in the local circuit. One line is connected to point *l* and the other to the arm *h*. The indicator *k* is an ordinary voltmeter with its scale marked to read in inches of water in the canal. If a high-resistance voltmeter is used, such as the Weston type, the reading will not be appreciably affected by accidental poor contact of the arm *h*. If there is no objection to running four line wires, it might be well to place the battery, resistance *f*, and indicator *g* at the other end of the line. It could then be seen at a glance whether the current through *d* was the right amount, and if not it could be adjusted. With good battery cells, the system should operate for some time without any great variation in the current.

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(148) Do you know of any book on the subject of brazing? BUILDER.

ANS.—"A Manual of Hard Soldering," by H. Rowell; price, 75 cents. This book may be obtained from The Technical Supply Co., Scranton, Pa.

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(149) Kindly let me know where "madstones" are found. J. B. R., New Orleans, La.

ANS.—Madstones, said by one authority to be "usually of the size and shape of an egg," are found by the ignorant and superstitious wherever ordinary stones are worn into striking shapes by the action of water. Their fortunate owners are said to find them very efficient in the cure of hydrophobia, but educated and skeptical people prefer the Pasteur treatment. In ancient times they were often picked up by Greeks and Romans, and were mistaken for thunderbolts "flung by angry Jove" at the earth or some of its offending inhabitants.

(150) (*a*) What are the advantages and disadvantages of surface and jet condensers? (*b*) What will prevent their satisfactory working? (*c*) What are the advantages and disadvantages of cross- and tandem-compound engines? (*d*) How is chimney draft measured in inches of water? (*e*) Why is it so measured? (*f*) What are the relative advantages in Corliss valves opening toward and away from the center of the engine? P. E. M., Lawrence, Mass.

ANS.—(*a*) Surface condensers are more expensive than jet condensers and require more water to condense a given weight of steam. If the condensing water contains impurities that will produce scale or injure the boiler, the surface condenser has the great advantage of permitting the pure water formed by the condensed steam to be returned to the boiler without the admixture of the impure condensing water. (*b*) An insufficient supply of condensing water is about the only thing that will prevent a well-designed condenser of either type that is properly connected to the steam cylinders, so as to be free from air leaks, from working satisfactorily. (*c*) Much depends on the conditions. In general, tandem-compound engines are cheaper and require less space, while the cross-compound type has the advantage of a steadier motion, on account of the arrangement of the two cranks at right angles to each other. (*d*) Chimney draft is measured by connecting one leg of a U-shaped glass tube having water in the bend with the interior of the chimney or flue, while the other leg is open to the air. The difference in pressure causes the water to rise in the leg attached to the flue and fall in the other. The difference in level, in inches, between the surfaces of the water in the two legs is the draft pressure in inches of water. (*e*) Principally because the water manometer applied in this manner is the most convenient method of comparing the small differences in pressure commonly found in chimney draft. (*f*) The principal difference is that valves opening away from the center of the engine give a slightly more direct passage for the steam than is obtained when they open in the opposite direction.

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(151) (*a*) Please give a list of electrical circuits that are called *non-inductive;* also, a list of non-inductive loads. Also, give a list of inductive circuits and inductive loads. (*b*) Give a recipe for a good leather-belt cement. (*c*) In looking at a switchboard a short time ago I saw in one of the circuits what seemed to be a short piece of corrugated tin about 1 in. wide and 6 in. long. What was it? J. B., Central Falls, R. I.

ANS.—(*a*) A non-inductive line circuit would be one in which the outgoing and return wires are run very close to each other, or are transposed at intervals. Incandescent lamps constitute a practically non-inductive load. A water resistance or an electrolytic bath are other instances of non-inductive loads. As an example of an inductive load, perhaps one of the most common is the induction motor. Synchronous motors under certain circumstances may also constitute an inductive load. Choke coils also introduce inductance into the circuit. Unless the lines are long, the inductance of the circuit itself is generally very small, and the character of the load depends on the kind of devices operated. (*b*) 16 parts gutta percha, 4 india rubber, 2 pitch, 1 linseed oil; cut small, melted together, and well mixed. (*c*) The switchboard appliance was no doubt a resistance of some kind. Very likely it was

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an ammeter shunt. It is not convenient to send the whole of the current through the ammeter, so it is usual to shunt the greater part of it through a low resistance, and allow only a small portion of it to flow through the instrument. This low resistance, connected in series with the main line and in parallel with the ammeter, is perhaps the resistance you refer to. It may also be possible that it was a resistance connected across the series-coils of the dynamo to adjust the compounding.

***

(152) Kindly publish the solution to the following problem, given in a recent civil-service examination: (*a*) Using a chord of 50 ft., what is the deflection angle for a curve of 265.84 ft. radius? (*b*) With a central angle of 86° 30′, what is the length of the curve? (*c*) What is the intersection angle, and how does it differ from the central angle as given?

W. R. B., Albany, N. Y.

ANS.—(*a*) In railroad work the formula commonly employed for finding the deflection angle when the radius of the curve is known is $\sin D = \frac{50}{R}$, in which D is the deflection angle and R the radius. This gives the deflection angle for a chord of 100 ft.; for shorter chords, proportional parts of this angle are taken. As the lengths of chords are not exactly proportional to the lengths of their subtended arcs, however, a slight error results from this. In curves of short radius, such as the one given in the example, it is desirable to employ a more exact method for the deflection angles for chords shorter than 100 ft. The exact formula for the deflection angle for chords of any length is $\sin D = \frac{\frac{1}{2}C}{R}$, in which C is the chord subtended by D. Applying the first method to the given example to obtain the deflection angle for a chord of 100 ft., we have $\sin D = \frac{50}{265.34}$, and $D = 10° 51′ 42″$, and the deflection angle for a chord of 50 ft., taken as one-half of this, will be 5° 25′ 51″. The exact formula gives, for the deflection angle for a chord of 50 ft., $\sin D = \frac{25}{265.84}$, and $D = 5° 24′ 23″$. (*b*) The number of chords of any length contained in the curve is found by dividing the center angle by twice the deflection angle for a chord of that length; or, in the present case, the number of chords 50 ft. in length contained in the curve is equal to $\frac{86° 30′}{2 \times (5° 24′ 23″)} = 8$ chords. Hence, the length of the curve measured on chords of 50 ft. is $8 \times 50 = 400$ ft. (*c*) The angle of intersection between the tangents is equal to the center angle of the curve.

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(153) (*a*) Of what does the mantle of a gasoline lamp consist, and how is it prepared so that when heated it will produce white light? (*b*) How is brass lacquered? (*c*) What is the reaction of sulphur 1 part and potassium chlorate 2 parts, by bulk, discharged by friction? (*d*) What is the cause of the noise made by bringing a piece of pipe or glass tubing about ½ or ¾ in. in diameter, and from 1 to 3 ft. long, over a hydrogen gas jet? (*e*) Explain the construction of a cantilever bridge.

J. H. E., Constantine, Mich.

ANS.—(*a*) The mantles of gasoline lamps, Welsbach burners, etc. consist of some finely woven fabric that is covered with a solution of certain rare metals, such as thorium, etc., which have the property of radiating white light when strongly heated. The process of manufacture is not known to us. (*b*) A good lacquer for brass is made by mixing 1 lb. turmeric, 2 oz. annatto, 12 oz. shellac, 12 oz. gum juniper, and 12 oz. alcohol. Apply with a brush. (*c*) Potassium chlorate is an explosive body when subjected to friction in the presence of a combustible body, such as sulphur. The explosion is caused by the friction, not by the action of the sulphur on the chlorate. (*d*) The noise is due to a series of continuous explosions, which are produced by the hydrogen mixing with the hot air in the glass tube. (*e*) A cantilever bridge, as commonly constructed, is one in which the principle of the cantilever is combined with that of the ordinary simple truss. A cantilever, in its simple form, is merely an arm projecting from a fixed support. Cantilever bridges are commonly constructed where the longest span between piers, which is usually the center span, is longer than is practicable for a simple truss. In such cases the span of the central truss is shortened by extending the trusses of the two adjacent spans across the piers toward each other as cantilever arms, and supporting the central span on the ends of these cantilevers.

***

(154) (*a*) How many red bricks are there to the cubic yard with ordinary mortar and with cement? (*b*) How many firebrick to the cubic yard? In laying these, is lime mortar or cement used?

M. P. C., McKeesport, Pa.

ANS.—(*a*) The number of bricks in a cubic yard varies materially with the thickness of the joints. It is customary in estimating to count 500 bricks to the cubic yard, which allows for joints ½″ thick. If the joints are ¼″ thick, as in face brickwork, 1 cu. yd. will require about 575 bricks. (*b*) The dimensions of firebrick are greater than those of common brick. There is, however, no standard size, and they vary so much that it would be impossible to give accurately the number per cubic yard. In laying firebrick where they are subjected to considerable heat it is customary to use fireclay. Cement mortar is never used where a high temperature is likely.

***

(155) Please give me a scheme for the analysis of coal or recommend a book containing the information.

R. H. F., St. Louis, Mo.

ANS.—We would recommend "Quantitative Analysis," by T. E. Thorpe, which you may obtain through The Technical Supply Co., Scranton, Pa. The December, 1899, number of the "Journal of the American Chemical Society" contains a report on coal analysis made by a committee of that society. You can get this number by sending 50 cents to the acting librarian, Mr. A. A. Brenneman, 97 Water St., New York. Modify the scheme given in Thorpe according to the above-named report.

***

(156) (*a*) What causes a bearing to squeak, and why will oil stop it? (*b*) What kind of gas would be formed by mixing equal parts of sulphuric acid and gasoline? (*c*) Would it burn? (*d*) Would it be explosive?

W. J. F., Pembroke, N. Y.

ANS.—(*a*) A probable explanation is that when the bearing is dry, the surfaces tend to seize each other; this causes one to slide over the other in a series of very short jumps, and sets up vibrations that produce the squeaking sound. Oil prevents the squeaking by interposing a thin film that prevents the surfaces from coming into actual contact. (*b*, *c*, and *d*) We do not know of any gas that would be formed.

***

(157) Will water in the steam chest of an Armington & Sims engine, running at 250 R. P. M., break the valve or rocker-arm? If so, please explain how.

A. B., Kingston, N. Y.

ANS.—It is possible that water in the steam might result in a broken valve or rocker-arm; in most cases, however, either the piston or cylinder head would break before enough water could collect in the steam chest to break the valve or rocker-arm.

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(158) With the following data, at what pressure will a safety valve blow off? Length of lever, 40 in.; distance from fulcrum to center line of valve, 4 in.; diameter of valve, 2½ in.; weight of ball, 75 lb. Give the rule and work out the example.

C. B., Philadelphia, Pa.

ANS.—Your question is incomplete, as you do not give the weight of the lever, nor the distance of its center of gravity from the fulcrum. Neither do you give the weight of the valve and stem. These data are essential, as without them your question cannot be answered. You will find an article explaining safety-valve problems in "The Steam-Electric Magazine," May, 1899, a copy of which you can obtain for 10 cents from The Colliery Engineer Co., Scranton, Pa. The subject is taken up at length, and fully discussed in the article entitled "Making a Steam Engineer."

***

(159) (*a*) What is the power of a steam jet? (*b*) After the jet catches its water, will it throw more water if more steam is turned on? (*c*) Will a jet lift water as far as a pump? A. H., Carbon, Ind.

ANS.—(*a*) We have no information regarding the actual power that can be obtained from a steam jet. The theoretical power in a jet of steam under known conditions can be calculated with considerable accuracy, but the part of the power that can be utilized in practice is very uncertain. (*b*) We think this depends on circumstances. Under certain conditions, as much steam may be required to start the water as can be utilized by the jet after the water begins to flow. (*c*) No.

***

(160) What is the simplest way to develop a cone, say for a phonograph or a speaking tube?

F. A. S., San Francisco, Cal.

ANS.—See SCIENCE AND INDUSTRY, December, 1899, Answers to Inquiries, No. 855. The method is the same as there given, but the dimensions will be slightly different in your case.

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(161) What is the process of vulcanizing a bicycle tire? A. E. T., Lowell, Mass.

ANS.—The rubber is immersed in a mixture of 30 parts of bisulphide of carbon and 1 part of chloride of sulphur. It is next placed in a room heated to 70°; and when all the sulphide of carbon has been volatilized, the process is so far complete that it is only necessary to boil the material in a solution of about 18 oz. of caustic soda to 2 gal. of water, the vulcanized rubber being next washed to remove excess of alkali.

***

(162) We propose building a sawmill to be run by water-power. We intend to build a dam 10 ft. high across a creek, and convey the water by flume about 400 ft. to the site where the mill is to be built. The total fall will be 40 ft. (*a*) Which is the better plan: (1) to flume the water direct to the waterwheel at the mill, following the nearly straight bed of the creek; or (2) to carry the flume along the nearly level outline of the bank of the stream to a penstock 40 ft. high at the waterwheel? (*b*) From which system would the most power be derived? (*c*) With 40 ft. fall and plenty of water in the creek, what size of flume and what size of Pelton waterwheel is necessary to furnish 100 H. P.?

L. K., Port Renfrew, B. C.

ANS.—(*a*) It is impossible to answer this question satisfactorily without knowing more about the conditions than is stated in the question. A choice between the two methods should be based on an estimate of their relative cost, and this must be based on a careful study of the site, and a knowledge of the cost of the different materials available for the construction of flumes and penstocks. If properly installed, either method will give satisfactory results. On account of the great irregularity and sudden changes in the amount of work required to run a sawmill it is probable that a penstock at the wheel would give better results than could be obtained by piping direct to the wheel; it might, however, be cheaper to pipe the water direct from the dam to the penstock than to bring it through a flume laid along the bank. If the latter method is used, care must be taken to make the flume large enough to carry the amount of water needed with a moderate slope. (*b*) The amount of power that can be obtained depends on the quantity of water and the available head. By giving the flumes correct proportions, the available head, and consequently the amount of power, that can be obtained with a given quantity of water may be the same in one case as in the other. (*c*) Under good conditions, the smallest flume that could be made to furnish 100 H. P. under the conditions named would be about 22 in. in diameter. With such a pipe, the available head at the wheel would be only two-thirds of the total head and more than 45 cu. ft. of water per sec. would be required. It is doubtful whether a Pelton wheel could be used to advantage under such conditions. Regarding this, we would advise you to consult the makers.

***

(163) (*a*) Please inform me what the difference is between high- and low-pressure boilers. (*b*) Is the engine the same? M. B. S., Becket, Mass.

ANS.—(*a*) We do not know of any definite line of distinction between a high- and a low-pressure boiler. A boiler used for generating steam at a low pressure, say 10 lb. per sq. in., for heating purposes is often called a low-pressure boiler. A boiler in which steam is generated at very high pressures for compound or triple-expansion engines is essentially a high-pressure boiler. One in which the pressure is more than would be safe for a boiler commonly used in house heating would be a high-pressure boiler when compared with the heating boiler, and a low-pressure boiler when compared with one used for generating steam at the high pressures sometimes used in locomotives or triple-expansion marine engines. (*b*) Compound or triple-expansion engines are most often used in connection with high steam pressures. With high pressures the various parts of the engine must, of course, be made stronger than would be necessary with lower pressures.

***

(164) (*a*) Please explain the difference between a dynamo and a motor. (*b*) What will keep crank-pins from getting hot, and also keep them from knocking? (*c*) What is a good compound for cleaning lubricators? (*d*) Is coal oil a good scale preventive? R. M. T., Logan, Ore.

ANS.—(*a*) There is very little difference between a dynamo and a motor. The difference is more in the nature of their action than in their mechanical construction; in fact, the same machine may be used as a dynamo or as a motor. In the case of a dynamo, the machine is run by means of a belt, and the energy supplied from the steam engine or other source of power is converted into electrical energy. In the case of the motor, electricity is supplied to the machine from some outside source, and this electrical energy reappears in the form of mechanical energy at the pulley. (*b*) Have everything in line and "square," and the brasses well together. See that the oil hole is clear, and that there is free and sufficient lubrication. Use a good quality of oil, and give the pins the right amount of freedom on the sides. (*c*) Put the lubricator in a bath of lye and hot water; afterwards rinse the lubricator well in clean water. (*d*) Yes; use it in moderation, injecting it with the feedwater. If you use too much you will cause foaming.

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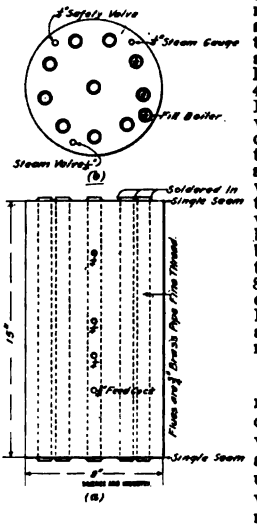
(165) In the accompanying illustration, (*a*) shows the elevation, and (*b*) the plan of a small steam boiler made for the purpose of thawing frozen pipes by injecting steam into them through a small flexible tube. I set this boiler over my plumbers' furnace and keep up 8 lb. of steam with a ¼-inch valve wide open. The boiler is made of galvanized sheet iron soldered together, and I am afraid of it, although I have had it tested with 40 lb. water pressure. I would like to know whether I can make one out of copper, as the solder does not stick well to iron. I want the copper one to stand about 20 lb. without danger of bursting. Would a boiler the same size as this, if made from 8-inch iron piping and caps, work as well and keep up steam as well as the sheet-iron one I now have? S. P., Stoughton, Mass.



ANS.—You can easily make a good boiler out of 20-oz. copper that will stand a fair amount of rough usage, and will work well, provided you do not let the water get too low and thus burn the soldered seams. We would advise you, however, to lock every one of your seams, rivet them and solder them as well, and then there will be very little liability of an explosion with a 20-lb. pressure. We do not think it advisable for you to make the boiler from 8-inch iron pipe and caps, because it would not only cost too much, but would be altogether too heavy for handling, and no doubt its weight would smash your fire-pot. It does not matter what materials you make your boiler of, but you must always remember to place a safety valve, a pressure gauge, and try-cocks on the boiler, otherwise your life will be in danger all the time you are working it.

***

(166) In SCIENCE AND INDUSTRY, November, 1899, Answers to Inquires, No. 290, it is stated that the distance between the cylinder head and the piston of a gasoline engine when the charge is compressed should be 2½ in. (*a*) What would be the result if the distance were 1½ in.? (*b*) Would it have twice the power? J. H. S., Canton, Ohio.

ANS.—(*a*) The charge would be compressed to about ⅓ of its original volume, instead of about ⅛, as was the case in the answer referred to. As a result, the pressure at the end of compression would be about 187 lb. per sq. in. (*b*) It is doubtful whether the power would be increased to any great extent. Experience shows that, taking all things into consideration, compressing the charge to about ⅓ of its original volume gives more satisfactory results than would be obtained if the compression were greater.

***

(167) If any supply pipe, filled with Croton water and having both ends capped so that there is no circulation of water in the pipe, is placed in the bottom of a salt-water river (at a depth of 40 to 60 ft.), when the temperature of the atmosphere is at zero, will the action of the salt water cause the fresh water in the pipe to freeze? D. J. D., New York City.

ANS.—Whether or not the fresh water in the pipe will be frozen depends on whether the currents in the river are such that water at a temperature below freezing is carried to the bottom in contact with the submerged pipe.

***

(168) (*a*) How are electric-car axles straightened? (*b*) Do you know of any device for doing this work? W. H. M., Akron, Ohio.

ANS.—(*a*) If the shaft is very badly bent, it will be a difficult matter to get it back to its former condition. If the shaft is only sprung, heat it red hot and mount it between the centers of a heavy lathe; spin the shaft and mark the high parts with chalk. By prying up against the high parts of the shaft with a lever it may be straightened. If you have a hydraulic press at hand, the bend might be taken out with the axle cold. It is, however, best to do the straightening in a lathe, because you can then tell when the shaft is true by revolving it. (*b*) We do not know of any device made specially for this work.

***

(169) Can electricity be used for heating purposes, and if so, how? A. D., Purissima, Cal.

ANS.—Electricity is quite extensively employed at the present time both for heating and cooking purposes. For heating a room or a street car, wire resistance coils, wound in spiral form, are supported on insulators and heated by passing current through them. Some forms of heaters are made by embedding resistance wires in enamel on the back of an iron plate. When the wires are heated by the passage of the current, the iron-plate surface acts as a radiator.

***

(170) What is the tensile strength of (*a*) cast iron, (*b*) copper, and (*c*) bronze? J. B. R., Philadelphia, Pa.

ANS.—(*a*) Ordinary cast iron varies in tensile strength, the usual range being from 15,000 to 20,000 lb. per sq. in. Special grades have higher strengths, the highest being what is sometimes known as *gun iron*, which may have a tensile strength as high as 35,000 lb. per sq. in. (*b*) Cast copper has a tensile strength of about 25,000 lb. per sq. in. When rolled, its tensile strength is about 30,000 lb. per sq. in., while hard-drawn wire may have a strength of 60,000 lb. per sq. in. (*c*) The word *bronze* is applied to a great number of different alloys having widely differing properties. Among the records of tests of bronze that we have, the highest tensile strength given is 44,071 lb. per sq. in. This is for an alloy of copper and tin in the respective proportions of 85.71 and 14.29. Various proportions of the two metals give strengths varying from the above down to less than 2,000 lb. per sq. in.

***

(171) (*a*) What should be the length and diameter of the large end of a horn that will have a range of 4 or 5 miles in good weather? (*b*) How can I make the horn out of old newspapers and wire for the ribs? (*c*) Can I use it on a phonograph? (*d*) Since the intensity of the heat from the sun varies as the square of its distance, why does it not melt the ice around the poles of the planets that are near the sun? S. T., Houston, Texas.

ANS.—(*a*) A horn that will have a range of about 2 miles should be 7 feet long and 3½ feet in diameter at the large end. We doubt whether one with a range of 4 miles can be made. Use two horns, one to speak into and the other as an ear trumpet. You might make larger horns, preserving, however, the same rate of taper or slant per foot as in the above horn. (*b*) Having given you the dimensions, you ought to be able to devise the wire frame yourself. Hard, smooth wrapping paper would be much superior to old newspapers. (*c*) Yes; but you will

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not get as good results as with the regular tin or brass horns. (*d*) Because the rays from the sun strike the polar regions at a very oblique angle, but along the equator they strike perpendicularly; consequently, fewer rays fall upon each square foot of surface and less heat is imparted per square foot at the poles than at the equator. Furthermore, the number of rays per square foot striking the polar regions of a planet near the sun may, on account of the oblique angle, actually be less than the number that strikes the equatorial regions of a planet much farther from the sun.

***

(172) The chord of a circular arc is 28 ft., and the length of the arc is 30 ft. (*a*) What is the diameter of the circle? (*b*) What is the area of the segment? (*c*) What is the altitude of the segment?

C. S. B., Paisley, Ore.

ANS.—(*a*) 46.947 ft. (*b*) 88.322 sq. ft. (*c*) 4.682 ft.

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(173) Please state the number of primary-battery cells that will be required to operate the medical coil described in SCIENCE AND INDUSTRY, January, 1900, Answers to Inquiries, No. 383.

J. McL., Bryson, Quebec, Canada.

ANS.—Two or three cells of dry battery will be enough to operate the coil.

***

(174) (*a*) What is the method of calculating the correct carrying capacity and resistance per step of an 8-step speed controller for a 75 H. P. 220-volt series motor? (*b*) What book contains information in regard to design and construction of rheostats?

T. M. B., Cleveland, Ohio.

ANS.—(*a*) In calculating the carrying capacity of a speed controller, it is necessary to determine the load in amperes that the controller must carry at the range of speed desired. If the speed varies directly as the load, and the amperes in the armature remain practically constant from full speed to half speed, the rheostat throughout must be designed to carry the maximum current. Take a 75 H. P. 220-volt motor with a load of 225 amperes. A No. 3 Washburn & Moen .244-inch gauge galvanized-iron wire will carry 63.8 amperes; 4 wires in multiple will carry $4 \times 63.8 = 255$ amperes. To have a drop of voltage on the controller of 110 volts, a total resistance of .43 ohm should be used; $.43 \times 255 = 109.6$ volts lost in the controller, which is half of the line voltage. The motor will now be running at 110 volts, and therefore at about half speed if the controller resistance is all in. With all the steps of the same resistance, $.43 \div 8 = .054$ ohm is the resistance of each step. A No. 3 W. & M. galvanized-iron wire has a resistance of 1 ohm for 645 ft. Each step consists of 4 coils in multiple; this gives a length of $645 \times .054 \times 4 = 139$ ft. for each coil in a step. There will be 4 coils in multiple, each 139 ft. long in every step. The resistance coils wound in spiral form may be placed in a strong framework made of iron water pipe, and should be carefully insulated from each other and from the frame. The contact head may be mounted on top of the framework or placed on the switchboard with cables leading to the resistance box. Instead of wire, strips of iron or other high-resistance material may be used, also cast resistance plates. (*b*) We do not know of any book treating solely on the design and construction of rheostats.

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(175) (*a*) If two 220-volt motors are connected in series and placed across a 500-volt circuit, will each motor take half of the load? (*b*) If the two 220-volt motors in series take 160 amperes, how can the H. P. of each motor be calculated? (*c*) When two 500-volt motors are in series across a 500-volt circuit, will No. 1 motor do the greater part of the work? (*d*) I have an induction coil that formerly worked well on one cell of battery, but after a short time it ceased to work properly. I have rewound it, but, running with two cells, it does not give satisfaction. Please explain the probable cause.

A. F. R., Harrisburg, Pa.

ANS.—(*a*) If both motors are of the same design and size, each motor should take half of the total load. If the magnetic qualities of the frames of the motors vary, the load may be divided unequally between the motors. (*b*) With a voltmeter, measure the voltage at the terminals of each motor. Then, $\frac{\text{volts of No. 1 motor} \times 160 \text{ amperes}}{746} = \text{H. P. of No. 1 motor}$; $\frac{\text{volts of No. 2 motor} \times 160 \text{ amperes}}{746} = \text{H. P. of No. 2 motor}$. (*c*) If both motors are of the same design and size, and their magnetic properties are the same, or nearly so, No. 1 motor should not do a larger share of the work than No. 2 motor. Each motor should take care of half of the total load. (*d*) It would seem that the coil might have absorbed moisture, which would act as a partial short circuit of the turns of wire in the secondary coil. Look carefully at the conditions of the connections of the coil and the contact maker, and then examine the strength of the cells. Bake out the coil to dispel the moisture.

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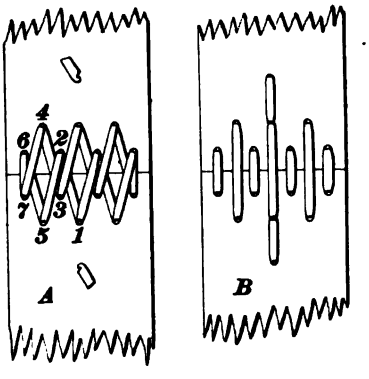
(176) (*a*) Please illustrate and describe the best method of erecting sheet-iron smokestacks from 80 to 100 ft. in height. (*b*) Show the best method of lacing belts.

L. B. R., East Plymouth, Ohio.

ANS.—(*a*) A comprehensive answer to this question will require more space than we can give it in these columns. (*b*) People differ a great deal in their ideas as to which method is the best. We illustrate one that we have tried on belts as wide as 10 in. and found entirely satisfactory. In the figure, *B* is the side of the belt next to the pulley. Draw



the lacing half way through hole *1*, then, for the left-hand side, pass the lacing through *2*, *3*, *4*, *5*, *6*, *7*, *4*, *5*, *2*, *3*. Lace the right-hand side in the same manner. For a 6″ belt, use 7 holes in each end, 4 in the row nearest to the end. For a 10″ belt, use 9 holes. The edge of the holes should not be nearer than ¾ in. to the edge of the belt; the first row should not be nearer than ¾ in. to the end of the belt, and the second row should be at least ¾ in. from the first.

***

(177) Is there any way by which I can tell whether an arc lamp used for street lighting is giving 2,000 candlepower or less? W. H. M., Boston, Mass.

ANS.—The term *2,000 candlepower*, as applied to an ordinary arc lamp, is misleading. As a matter of fact, an ordinary arc lamp gives about 500 candlepower. A so-called 2,000-candlepower arc lamp

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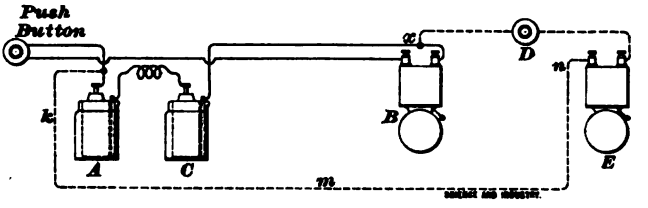
is now taken as one that consumes 450 watts; i. e., if the product of the current flowing through the lamp by the pressure across its terminals is 450, the lamp is up to the required standard. In fact, many electric-light companies now guarantee to supply so many watts per lamp, instead of stating that the lamps will be of 2,000 or 1,200 candlepower. These terms were originated when arc lighting first came into use, and when very little was known as to the actual candlepower of the arc. Test the lamps with an ammeter and voltmeter, and if they show a consumption of 450 watts, they may be assumed to be standard.

***

(178) The accompanying sketch illustrates the connections of an electric bell on the first floor. (*a*) Can another bell be connected above *B*, in the second story, with a push button in the adjoining room? (*b*) Can the connections be so made that when the button on the second story is pressed it will ring the



second-story bell only? (*c*) Will two cells be sufficient to operate these bells? (*d*) Please give titles of some good books on electricity and architecture.

W. T. G., St. Louis, Mo.

ANS.—(*a* and *b*) The dotted lines show the connections necessary for the additional bell and push button. The wire *Dx* connects from the push button to one battery wire, and the other line *kmn* connects from the bell to the other side of the battery. (*c*) Two cells should be sufficient to operate the bells, unless your lines are unusually long. (*d*) For works on electricity we can recommend "Elementary Lessons in Electricity and Magnetism," by Silvanus P. Thompson; "Dynamo-Electric Machinery," by Silvanus P. Thompson; "Electric Lighting," by Crocker; "Electric Transmission of Energy," by Abbott. For works on architecture we can recommend "Gwilt's Encyclopedia of Architecture," revised by Wyatt Papworth; and "The Architect's and Builder's Pocketbook," by Kidder. These books are for sale by The Technical Supply Co., Scranton, Pa.

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(179) A flywheel connected to a punching press runs at 250 rev., is 60″ outside diameter, and 49″ inside diameter, the rim weighing 1,280 lb., approximately. What pressure on the tooth of a pinion, 16″ in diameter and keyed to the flywheel shaft, will cause a retardation of not more than 20% of the speed of the wheel? F. I. E., Pittsburg, Pa.

ANS.—You do not specify the length of time within which the retardation is to take place. Call this time t seconds; let P = pressure on pinion, I = moment of inertia of flywheel, and r = radius of pinion = $\frac{1}{3}$ ft. Then, $\frac{Pr}{I} = \gamma$, where γ is the angular retardation per second. The original angular velocity $U = \frac{2N\pi}{60}$, where N = number of revolutions per minute. After t seconds, this velocity will be reduced by 20%, so that $t = \frac{.2U}{\gamma} = \frac{.2 \times 2N\pi}{60\gamma} = \frac{.2 \times 2N\pi I}{60Pr} = \frac{N\pi I}{150Pr}$. Then, $P = \frac{N\pi I}{150rt}$. (*a*) The moment of inertia of the flywheel, neglecting the hub and arms, $= \frac{W}{g} \times \frac{R^2 + R_1^2}{2}$, where W = weight of rim, $g = 32.16$, R = outer radius, and R_1 = inner radius. Substituting values, we get $I = \frac{1,280}{32.16} \times \frac{25 \times 24.01}{2} = \frac{1,280 \times 6,001}{32.16 \times 288}$. Substituting this value of I in formula (*a*), we get

$$P = \frac{250\pi \times 1,280 \times 6,001}{150 \times \frac{1}{3} \times t \times 32.16 \times 288} = 6,512.0285 \times \frac{1}{t}.$$

If the time in which the flywheel would slow down 20% were 1 sec., the pressure P would be 6,512.0285 lb. In a punching press, all the work is done practically in one-quarter of a revolution; hence, $t = \frac{1}{4} \times \frac{60}{250} = .06$ sec. Then, $P = \frac{6,512.0285}{.06} = 108,533.81$, or 54¼ tons, nearly.

***

(180) I would like to know how to estimate the size and spacing of the hoops for any size wooden cylindrical water tank. Is there any way of figuring the strain produced by the swelling of the wood when the tank is filled?

A. M., Pawtucket, R. I.

ANS.—The pressure on any point in the tank in lb. per sq. in. is equal to the depth in feet of water above the point in question multiplied by .43. The bursting pressure at any section of the tank, considering 1 in. of height, is equal to $P \times R$, where P = pressure in lb. per sq. in., and R = radius of tank in inches; the dimensions of the hoops are assumed, and their tensile strength calculated by multiplying the net sectional area by the unit tensile strength of the material. For instance, assume that round wrought-iron hoops ¾ in. in diameter at the least section are to be used; the sectional area of these hoops is then .44 sq. in.; and, as the safe unit tensile stress that wrought iron will sustain is approximately 10,000 lb., each hoop will carry .44 × 10,000, or 4,400 lb., with safety. If the tank under consideration contains 15 ft. of water, the pressure at the bottom is equal to .43 × 15, or 6.45 lb. per sq. in.; and if the tank is 30 ft. in diameter, the bursting pressure for a space of 1 in. from the bottom is, according to the formula, $P \times R = 6.45 \times 180$, or 1,161 lb. The bottom hoop will, therefore, provide for the lower 4 in. of the tank. The next hoop can be figured in the same manner, reducing the pressure due to 4 in. less in the depth of the water. The increased stress created by the swelling of the wood in the tank can hardly be made a subject of calculation, and the factor of safety used, which in the preceding example is from 4 to 5, will provide for this.

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(181) (*a*) Can you recommend a book that contains drawings of stationary, locomotive, and marine engines and boilers, from which I could make tracings and blueprints for practice work? (*b*) Are there any restrictions on making blueprint paper by the method described in the "Mechanics' Pocket Memoranda"?

J. F. D., Boston, Mass.

ANS.—(*a*) We do not know of any single book that contains drawings suitable for tracings of the three different classes of engines. Most of the drawings published in books are made to such a small scale as to make the work of tracing them rather difficult. The following are probably as good as any that can be found: For stationary work, "A Treatise on Steam Engines," by Arthur Rigg, price, $10; for locomotives, "Modern Locomotives," by Barnes & Whitridge, price, $7; for marine engines, "Modern American Marine Engines," by Emory Edwards, price, $5.

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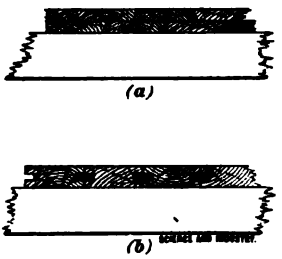
Any of these books can be obtained from The Technical Supply Co., Scranton, Pa. (*b*) No. Any one is at liberty to use this process.

***

(182) (*a*) What is the comparative strength of the two systems of floor construction shown in the accompanying sketch? In Fig. (*a*) the floor is composed of two thicknesses of 1-inch boards laid so as to lap joints, and the system shown in Fig. (*b*) is formed of 2-inch planks grooved and fitted together with tongues as designated. (*b*) Which will be the more durable as a driveway for heavy wagons? (*c*) A number of shingle roofs put on 3 or 4 years ago with steel-wire nails have had to be renewed because of the nails rusting off. Do all steel-wire nails rust so quickly, and are wrought nails better in this respect? (*d*) Is there any process in manufacturing steel-wire nails that subjects them to liability of corrosion?



J. B. M., Nova, Ohio.

ANS.—(*a*) The floor in Fig. (*b*), if well nailed, is within 80% as strong as that shown in Fig. (*a*). (*b*) The floor formed of the two layers of planking, as designated in Fig. (*a*), is more durable, because when the top layer wears out it can be renewed, the under layer having been unimpaired. We would, however, suggest that, if the loads are heavy, a 2- or 3-inch rough plank flooring be used, with 1½- or 2-inch top flooring. (*c*) The rusting of nails holding shingles in place is due to capillary attraction, the nails by this action drawing water to them. Wrought nails seem to be better for this purpose, as their surface, on which more or less of a skin has been formed, seems to be more impervious to rust than that of steel-wire nails. (*d*) As you suggest, the process employed in making the nails might have considerable to do with the relative values in resisting corrosion. For instance, wire nails after being formed are, we understand, pickled in an acid to clean and brighten them. This pickling process might have something to do with their subsequent rapid deterioration. We are, however, not prepared to state positively in regard to this.

***

(183) (*a*) I have a piece of platinum wire 2 in. long that I want to use for igniting gunpowder. Could you give me directions for making the simplest and smallest form of battery to heat the same? The wire is No. 18 B. & S. gauge. (*b*) Will the wire become hot by a tap on a push button? (*c*) What kind of acid is used to solder platinum wire to copper wire? F. L., Chicago, Ill.

ANS.—(*a*) We would advise you to take this platinum wire to a jeweler and have it drawn down to about No. 28 or 30 B. & S. It will take too much current to heat a No. 18 wire. Use two or three cells of dry battery to heat the wire. A battery of the type used to operate small electric bicycle lamps would answer very well. (*b*) The button would have to be pressed for a short interval to give the wire time to become hot, but if the wire were very fine, it would heat up almost instantly. (*c*) The best way to fasten platinum wire to copper wire is not by soldering, but by fusing the end of the copper wire and sticking the end of the platinum into the molten bead of copper that forms on the end of the copper wire. You can easily fuse the end of the small copper connecting wire (about No. 20 or 22 B. & S.) by holding it in the edge of a Bunsen flame. As soon as the bead forms, stick the end of the platinum into it, and withdraw the joint from the flame. The two wires will then be firmly connected together.

***

(184) We have a 35 H. P. water-bottom cast-front semiportable boiler (locomotive type) that does not furnish steam enough for our purpose. As a remedy I have suggested walling the boiler in with a furnace under the waist, and permitting the hot gases to pass back under the water bottom, thence through the present front of the firebox to the tubes, thus converting it into an externally-fired return-tubular boiler. (*a*) Do you think this plan would be feasible? (*b*) How much would be gained in steaming capacity by the change? (*c*) Please give me some directions for the proportions to make the passages, etc. (*d*) Could I use the present furnace fittings and grates? The fuel used is green slabs with some dry wood. R. E. P., Elton, Ga.

ANS.—(*a*) While such a scheme would doubtless give you quite an increase in the steam-making capacity of your boiler, we do not think it is to be recommended. It would be difficult to properly inspect and care for the water legs and bottom, and considerable extra care would be necessary to prevent overheating, and to guard against the serious danger of explosion. We think most boiler insurance and inspection companies would object to a setting such as you suggest. (*b*) From your description and sketch it is difficult to make an estimate of the probable gain. Although there would be a considerable increase of heating surface, the heating surface of the firebox and tubes would be much less effective than it now is. (*c*) We would advise making the furnace as wide as the outside of the present shell, and long enough to permit slabs at least 6 ft. long to be fired. To connect the furnace with the present front, the area of the passages should nowhere be less than the area of the stack. Great care should be exercised to provide for inspection of all parts of the shell. The blow-off connection should be moved from its present position to the opposite end of the water bottom. (*d*) The present cast-iron front could be used. It would probably be better to use larger grates than you now have.

***

(185) We have had a number of complaints registered at our club, stating that the shower-bath floor is disagreeably cold, owing to the fact that the bath is not used continually. The floor, which is cemented at present, does not have a chance to become properly warmed. A wooden rack placed on the floor to stand upon was found very unsatisfactory, on account of our inability to keep it sweet and clean. Wood is absorbent, and is capable of taking in germs, which cannot be washed off. Can you suggest anything that will give more satisfactory results? C. F. A., Buffalo, N. Y.

ANS.—If your club can afford to lay the bathroom floor with interlocking rubber tile, as manufactured by the New York Belting and Packing Co., 25 Park Place, New York, you will get not only a warm floor but a non-absorbent and waterproof floor. This material, we believe, will be very satisfactory, provided it is not deluged with scalding hot water, which is most unlikely in a bathroom. We would advise you to communicate with these people. Cork mats are often used to step on, when coming out of a bath, but they are not non-absorbent, and may retain disease germs.

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(186) Kindly explain why the induced current from a Ruhmkorff coil does not set up lines of force so as to be able to magnetize.

C. G. A., Kingston, Jamaica.

ANS.—If the current from a Ruhmkorff coil is sent around an ordinary electromagnet, the magnetizing effect produced will be very weak, because the

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current furnished by the coil is exceedingly small in volume; consequently, the ampere-turns set up are very small. Moreover, the current furnished by the coil is alternating, so that whatever magnetizing effect there might be would be periodically reversed, thus greatly reducing the power of the magnet to attract or hold an armature.

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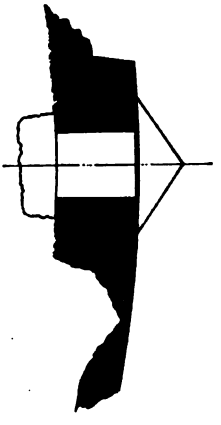
(187) (*a*) Where can I get a book on steam boilers and steam pumps? (*b*) How can it be known whether there is a break in a force line, and how can such a break be found? (*c*) What is *grooving* in a boiler? G. J. M., Olean, N. Y.

ANS.—(*a*) "Boilers and Furnaces," by Wm. Barr, price, $3; and "Pumping Machinery," by the same author, price, $5, are excellent. They may be obtained from The Technical Supply Co., Scranton, Pa. (*b*) We do not know of a method by which it can be definitely known when a break occurs in a long force-pipe line. If the break is a large one and near the pump, its existence would be indicated at once by a drop in pressure in the line. If it is small or near the discharge end of the line, the drop in pressure at the pump end of the line might not be great enough to show that a break had occurred. We do not know of any method for finding a break except to examine the line for leaks. A sudden and large drop in pressure at the pump would, however, be an indication that the break was near that end of the line. (*c*) *Grooving* is generally caused by the buckling action of the plates when under pressure. Thus, the ordinary lap joint of a boiler distorts the shell slightly from a truly cylindrical form, and the steam pressure tends to bend the plates at the joint. This bending action is liable to start a small crack along the lap, which, being acted on by corrosive agents in the water, soon deepens into a groove, as shown in the figure. The mark made along the seam by the sharp calking tool, when used by careless workmen, is almost certain to lead to grooving.



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(188) (*a*) Are there any books treating on the subject of expanding and beading flues? (*b*) Name a few threshermen's papers with their places of publication. (*c*) How should *digest* (to dissolve in the stomach) be pronounced? (*d*) How should crankpins and crosshead pins be made round after they are worn oval? They cannot be removed. (*e*) An engineer claims that it is easier to make steam with damp straw than with dry. Is such a claim reasonable? (*f*) How can long skate blades be hardened uniformly without warping? (*g*) How are small springs tempered? (*h*) How is a telegram directed to a certain office when there are many offices on the same line? J. T., Watson, Minn.

ANS.—(*a*) We do not know of any book that deals exhaustively with this subject. Nearly all books on steam boilers give some simple directions as to how the work should be done, but they do not give much practical information. The best information on the subject with which we are acquainted is found in an article in "The Locomotive," for September, 1898. This paper is published by The Hartford Steam Boiler Inspection and Insurance Co., Hartford, Conn. If the edition is not exhausted, you can probably get a copy from the publishers. (*b*) "The American Thresherman," Madison, Wis.; "The Thresher World," Milan, Ohio; "The Threshermen's Review," Port Huron, Mich. (*c*) *Di-gest'*, with the soft sound of *g* and the accent on the last syllable. (*d*) Some repair shops have a special machine designed for this purpose, by means of which a crankpin or wristpin can be turned up in place. In general, however, they are made round by filing them. They are finished by draw-filing with a very fine file, and in good work are often oilstoned after draw-filing. (*e*) Our experience in burning straw has been too limited to allow us to express a definite opinion. Reasoning from analogy, however, it does not seem probable that damp straw should give out more heat than dry straw. (*f*) There is no way of accomplishing it with any degree of certainty. Work of this character is usually straightened after hardening. (*g*) After hardening them in water they are thrown into an iron pot containing whale oil. This is placed on a blacksmith fire and the oil is heated until the vapor driven off ignites. The springs should be stirred up continually. The pot is then removed from the fire and allowed to cool slowly. We have used this method for tempering small flat springs, in lots of 500, and obtained excellent results. (*h*) Every telegraph office has a name or call, which consists of one or two letters. If one office desires to communicate with another on the same line, the sending operator repeats the call for the office desired until answered. The operator at the office called opens his key and replies by repeating "I" several times, and signing his own office call. The other offices on the same line, not hearing their own call, do not reply.

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(189) Is there any process by which blueprinting can be done by electric light; if so, does it require a special blueprint paper? H. H. S., Erie, Pa.

ANS.—Blueprints can be made under a very powerful arc electric light if the frame is placed very close to the luminous arc. The exposure is from 5 to 20 times that required for sunlight, varying according to circumstances.

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(190) (*a*) Having an assayer's ordinary soft-coal muffle furnace (muffle 12″ × 18″ × 17″), what is the best method, without cupellation, of separating gold from rich silicious ores (value $1.50 to $5 per lb.)? Give amount of flux to use to 1 pound of ore. (*b*) Can the gold values in high-grade tellurium ores be saved without using flux requiring cupellation? If so, kindly state how it should be fluxed.
G. J. E., Durango, Col.

ANS.—(*a*) In the case of a rich gold ore, such as mentioned, if the gangue were pure silica, the metal could be obtained by melting it with 5 times its own weight of a flux composed of equal parts of potassium and sodium bicarbonates. There would be some danger of small globules of metal not separating properly from the large mass, and it would be better to add litharge and a reducing agent and then cupel the resulting lead-gold button. Another way of recovering any globules of metal from the mass would be to crush it and pan out the gold. (*b*) In the case of a high-grade tellurium ore, the tellurium can first be driven out by roasting the ore, after which the ore may be smelted with a flux like that employed in case (*a*), though in this case there will also be danger of losing small globules of the metal; hence, it is usually best to wash out the gold with lead and recover it by cupeling. Another method of separating the gold from the tellurium ore is to roast the ore, crush it, and pan out the gold.

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SCIENCE AND INDUSTRY

Vol. V MAY, 1900 No. 4

TAPERS

"Spacer"

EXPLANATION OF THE TERM—HOW TO FIND THE TAPER PER FOOT—CALCULATING THE SETTING OVER OF THE TAILSTOCK—CUTTING THREADS ON TAPERS

OF THE many problems that the machinist meets with in his daily work, those relating to cutting tapers on a lathe occur very often; and they seem to be rather difficult to many machinists, judging from the inquiries relative to them that we receive from our readers. Hence, the writer offers the following as a contribution to the literature of the subject.

First of all, let us consider what is meant by taper. At (*a*), Fig. 1, is shown a wedge, the end of which, *ts*, is perpendicular to the side *rs*. The side *tr* is said to *taper*, or *slope*, towards the side *rs*. At (*b*) is shown another wedge, the end of which, *ts*, makes equal angles with the sides *rt* and *rs*. In fact, if this wedge were cut along the dotted line *rn* the result would be two wedges of the same size as shown at (*a*). At (*c*) is shown still another wedge, which, if cut along the dotted line *rn*, will make two wedges 12 inches long; one being 1 inch high and the other 2 inches high.

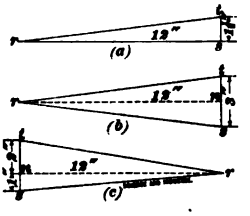

FIG. 1

It is customary to designate tapers as so many inches or fractions of an inch per foot, meaning thereby that in the case of (*a*), Fig. 1, if a point *s* be laid off on the line *rs* 12 inches from the point *r* of the wedge and a line *st* be drawn perpendicular to *rs*, the length of *ts* in inches will be the taper in inches per foot. The taper of the wedge (*a*), Fig. 1, is 1½ inches per foot. We could designate the wedge shown at (*b*) as a *double* wedge having equal tapers of 1½ inches per foot and that shown at (*c*) as a double wedge having tapers of 1 inch and 2 inches per foot, and this is often done. In practice, however, the wedge shown at (*b*) is usually referred to as a wedge having a taper of 3 inches per foot, and this has resulted in more or less confusion, as will be presently shown.

In Fig. 2 is represented a key, the top surface of which slopes towards, but does not meet, the bottom surface. To find the taper we draw a line *rs* parallel to *ab* and another line *ts* perpendicular to *rs*. In the present case, *rs* is 12 inches and *ts* is 1½ inches long. Hence, the taper is 1½ inches in 12 inches, or 1½ inches per foot.

In Fig. 3 is shown a rod 6 inches in diameter, which has been turned down to 3 inches in diameter, the length of the taper being 12 inches. The distance $st = s't' = 1\frac{1}{2}$ inches (the lines *rs* and *r's'* being parallel to the center line of the rod). How shall we designate the taper? It would seem better to designate it as 1½ inches per foot, but the common practice in shops is to subtract the diameter at the small end from the diameter 12 inches from it and call the difference the taper. The taper then becomes, for the piece shown in Fig. 3, 3 inches per foot—just twice as much as when *ts* or *t's'* is measured. The case is analogous to that of the wedge shown at (*b*) in Fig. 1, and as some persons designate the taper one way and some the other, much confusion has frequently been caused. So far as pieces turned in a lathe are concerned, it has become the recognized practice to calculate the taper by the following rule, which will be used throughout the remainder of this article:

RULE.—*Divide the difference in inches between the diameters at the large and small ends of the taper by the distance between the ends* (*measured*

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in inches parallel to the axis) and multiply the quotient by 12. The result is the taper in inches per foot.

For example, if the length of the taper is $7\frac{1}{2}$ inches, the diameter at one end is $4\frac{1}{4}$

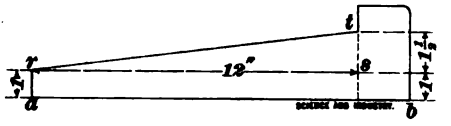

FIG. 2

inches, and at the other end is $4\frac{3}{4}\frac{3}{2}$ inches, the difference between the diameters is $4\frac{3}{4}\frac{3}{2} - 4\frac{1}{4} = \frac{1}{3}\frac{3}{2}$ inch; $\frac{1}{3}\frac{3}{2} \div 7\frac{1}{2} = \frac{1}{3}\frac{3}{2} \div \frac{1}{1}\frac{5}{0} = \frac{1}{3}\frac{3}{2} \times \frac{2}{1}\frac{0}{5} = \frac{1}{1}\frac{1}{6}$; and $\frac{1}{1}\frac{1}{6} \times 12 = \frac{1}{1}\frac{2}{6} = \frac{3}{4}$ inch. That is, the taper is $\frac{3}{4}$ inch per foot.

It will be noticed that the result of the first operation, $\frac{1}{1}\frac{1}{6}$ inch, is the taper per inch; hence, if it is desired to find the increase or decrease in diameter between any two points on a taper, we multiply by the distance between the points selected instead of by 12. Thus, the increase in diameter of the foregoing taper between two points 5 inches apart is $\frac{1}{1}\frac{1}{6} \times 5 = \frac{5}{1}\frac{5}{6}$ inch.

Suppose we have a rod 22 inches long and $1\frac{1}{2}$ inches in diameter, and that it is to be tapered for the first 8 inches of its length, the taper to be $\frac{5}{8}$ inch per foot; what will be the diameter at the small end? Since the taper is $\frac{5}{8}$ inch per foot, it is $\frac{5}{8} \div 12 = \frac{5}{9}\frac{5}{6}$ inch per inch; hence, the decrease in diameter is $\frac{5}{9}\frac{5}{6} \times 8 = \frac{5}{1}\frac{5}{2}$ inch, and the diameter at the small end is $1\frac{1}{2} - \frac{5}{1}\frac{5}{2} = 1\frac{1}{1}\frac{1}{2}$ inches.

There are a number of ways by which a taper may be cut in a lathe, some of which

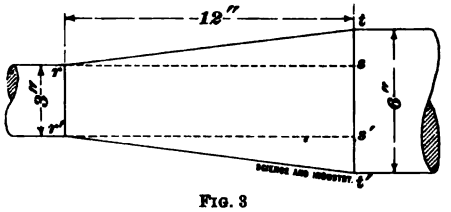

FIG. 3

are as follows: (1) By constantly feeding the tool towards or from the work while the carriage is moving. This may be done by hand or automatically. (2) By moving the dead center out of line with the live center. (3) By using a taper attachment. (4) For work held in a chuck, some lathes are so arranged that the headstock can be swiveled to make an angle with the shears. (5) By means of a compound rest.

The third, fourth, and fifth methods are the best, as they will produce the most accurate work. The first method is only applicable to rough work, or roughing out, when the feeding of the tool is done by hand. When so arranged that the feed-traverse and the cross-feed screw can be worked together automatically, accurate work can be produced. This arrangement is rather limited in its range and not applicable to every lathe. The second method is the one most frequently used for outside work, and the one to which we shall confine ourselves in this article. It is also applicable to inside work where the hole extends through the work, when a splined arbor carrying a loose sleeve with the cutting tool fastened to it is used. The arbor then remains stationary between the centers, and the sleeve is fed along the arbor.

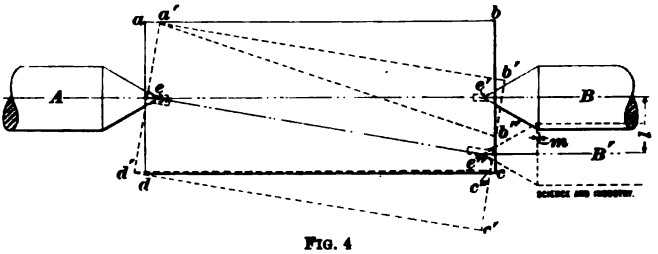

FIG. 4

In Fig. 4, A is the live center and B the dead center, their axes being in line, and $a\,b\,c\,d$ is a cylindrical piece of work on which it is desired to cut a taper. Now, if the dead center be moved towards the tool post so as to occupy the position B', the work will then occupy the position $a'\,b'\,c'\,d'$, and it is evident that if the tool be placed at d' and the carriage moved to the right, the tool will cut into the work, emerging at c'' when it reaches the end of the piece; in other words, the tool will cut a taper groove, whose outline will be $d'\,c''\,c'$. Hence, if the work be set revolving on the centers A and B' and the tool caused to travel from the end d' to c'', the result will be the tapered piece $a'\,b''\,c''\,d'$.

A part or all of the foregoing is well known to every machinist, and the question naturally arises "How can I calculate the distance l that the dead center must be shifted to cut any required taper?" It will now be shown that it is impossible to calculate this distance, but it can be approximated so closely that

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the taper can afterwards be easily found by trial. For example, suppose that the piece $a\,b\,c\,d$ is 10 inches long, and it is desired to cut on it a taper of $\frac{1}{2}$ inch per foot. The taper per inch is $\frac{1}{2} \div 12 = \frac{1}{24}$, and for 10 inches, $\frac{1}{24} \times 10 = \frac{10}{24}$ inch. Now, since the tool cuts off not only the amount $d'\,c'\,c''$ but also the equal amount $a'\,b'\,b''$, it would seem that if the dead center were shifted the distance $l = \frac{1}{2}$ of $\frac{10}{24}$ inch $= \frac{5}{24}$ inch, the resulting taper would be the one required. Again, suppose the piece $a\,b\,c\,d$ is 10 inches long and that it is desired to turn somewhere on it a taper $3\frac{1}{2}$ inches long, the diameter at the one end of the taper being $1\frac{1}{8}$ inches, and at the other end 1 inch. The taper per inch would then be $(1\frac{1}{8} - 1) \div 3\frac{1}{2} = \frac{1}{8} = \frac{1}{28}$, and for 10 inches $\frac{1}{28} \times 10 = \frac{10}{28}$; then it would seem as though the proper amount to shift the dead center would be $\frac{10}{28} \times \frac{1}{2} = \frac{5}{28}$ inch.

It will be found, however, that when the dead center is shifted the amount calculated, the resulting taper will not be the one required, but will vary from it by an amount depending on the distance l and through other causes that will now be mentioned.

1. When the piece on which the taper is to be cut is drilled with a center drill and *countersunk*, as it should be in work of this kind, the length $a\,b$ is not the correct length to use when calculating the distance l, for the reason that the lathe centers do not necessarily bear on the outer edges of the countersinks, or, at any rate, will not do so after the countersinks have worn.

2. When the dead center is shifted, it moves in a straight line, and the distance $e\,e'$ between the ends of the centers increases; hence, in order to make $e\,e''$ equal $e\,e'$, the dead center must be advanced an amount depending on the distance l. If it were not for the countersinks, this distance in Fig. 4 would be the difference between $d'\,c$ and $d'\,c''$, and could be easily calculated. In practice, however, by reason of the countersinks, the dead center will not advance this amount; just how far it will advance cannot be determined—it will depend on how tightly the dead center is screwed against the work.

3. Even though both (1) and (2) could be allowed for, it would still be impossible to calculate the amount that the dead center must be shifted, owing to the wear on the countersinks. The amount of wear will not be the same in any two pieces; it will depend on the hardness of the material (both where the tool cuts and at the countersinks), on the amount of material removed, and on the depth of the cut. Both countersinks will wear—that touching the dead center more than the one touching the live center.

In short, it is impossible to calculate exactly the amount to shift the dead center. In fact, if two pieces, exactly alike in every respect, were drilled and countersunk exactly alike, and one piece were to be cut to the correct taper, the other piece could not be cut to the same taper without shifting the dead center slightly one way or the other. If the second piece did have the same taper it would be purely accidental—as much of an accident, in fact, as though the dead center had been shifted to the correct position on the first trial.

The writer here takes the opportunity to answer another question that is frequently asked, namely: "After a taper has been turned in the manner just described, and it is required to cut a thread on it, should the thread tool be set at right angles to $e\,e'$ or to $e\,e''$?" He answers as follows: "The thread tool should always be set at right angles to $e\,e''$, the center line of the taper."

A NEW USE FOR THE PHONOGRAPH

THE phonograph has long ago ceased to be merely a scientific toy, and has made for itself a large field of usefulness in several departments of commercial life. Recently, however, it has been proposed to employ the phonograph as an aid in learning foreign languages, and in this department it will probably prove of more signal advantage than in any field where it has as yet been employed. In learning a foreign language it is necessary first of all to have the ear trained to catch and recognize the sounds, and the only way to accomplish this is to listen to the continual repetition of the sounds until the ear becomes familiar with them. Many persons have to learn a foreign language without any aid from a teacher that can speak that language correctly, and even those that are so fortunate as to have a competent teacher cannot constantly have the teacher at hand. Now it is proposed to have phonographic records of language lessons; then the student can have the machine repeat the lesson over and over again, until he is perfectly familiar with it.

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MECHANICAL DRAFT AND OPERATING EXPENSES

Walter B. Snow

ITEMS THAT DETERMINE THE OPERATING EXPENSES—ABILITY TO BURN LOW-GRADE FUEL. THE SAVING DUE TO LOW-GRADE FUEL

ALTHOUGH many items enter into the determination of the operating expense of a boiler plant, by far the most important of these factors is the cost of the fuel. Fuel cost is not to be based simply on the price paid for a given weight, for it depends primarily on the number of heat units available. The cost of producing a given amount of steam is the ultimate criterion by which any fuel should be judged. The commercial efficiency not only concerns the amount of water evaporated by a pound of fuel, but is directly dependent on the following items of expense:

1. Interest, rent, taxes, insurance, and the depreciation of the plant.
2. Repairs.
3. Cost of the water from which the steam is generated.
4. Labor.
5. Getting rid of the ashes.
6. Cost of the fuel in the boiler house.

The first item is, to a considerable extent, dependent on the character of the fuel, for with a very low-grade fuel that is actually low in first cost per heat unit, it is frequently necessary to introduce special devices, either in the form of stokers, grates, or smoke-consuming contrivances, to make possible the successful combustion of the given fuel. But, when burned under suitable conditions, the decrease in cost of fuel usually far outstrips its decrease in efficiency, so that the solution of the problem involves itself with the provision of the proper conditions that can usually be introduced at such cost as to show a generous return on the investment.

As a rule, the cheap fuels, like the fine anthracites, require for their combustion an intensity of draft that the ordinary chimney is incapable of producing. This is well exemplified by Tables I, II, and III. Table I indicates the theoretical draft produced by a chimney 100 feet high under different conditions of internal and external temperatures, and incidentally illustrates the effect of cold winter weather in increasing the efficiency of the chimney.

With an external temperature of 60° and a flue-gas temperature of 500°, it is to be noted that the drop is only .639 inch of water.

The pressures required for the burning of fine anthracite of various grades, as determined by Coxe in connection with his traveling grate and a fan-producing pressure of different intensities in compartments

TABLE I

HEIGHT OF WATER COLUMN DUE TO UNBALANCED PRESSURE IN CHIMNEYS 100 FEET HIGH

Temperature in Chimney.	Temperature of External Air					
	0°	20°	40°	60°	80°	100°
200°	.453	.384	.321	.263	.209	.157
220°	.488	.419	.355	.298	.244	.192
240°	.520	.451	.388	.330	.276	.225
260°	.555	.484	.420	.363	.309	.257
280°	.584	.515	.451	.394	.340	.288
300°	.611	.541	.478	.420	.367	.315
320°	.637	.568	.505	.447	.394	342
340°	.662	.593	.530	.472	.419	.367
360°	687	.618	.555	.497	.444	.392
380°	.710	.641	.578	.520	.467	.415
400°	.732	.662	.598	.541	.488	.436
420°	.753	.684	.620	.563	.509	.457
440°	.774	.705	.641	.584	.530	.478
460°	.793	724	.660	.603	.549	.497
480°	.810	.741	.678	.620	.566	.515
500°	.829	.760	.697	.639	.586	.534

beneath the fuel, are presented in Table II. This serves to show particularly well the difference in pressure required at different stages of the process of combustion. But Table III best indicates the effect of size of coal.

Here the maximum limit to size of the coal is given, and it is to be noted that there is a steady increase in the air pressure required that corresponds to the decrease in the size of the coal. The rates of combustion

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are all comparatively low, particularly in the case of the Eckley No. 3 buckwheat, which has a maximum size limit of $\frac{3}{16}$ inch, where it is only 9.44 pounds per square foot of grate per hour. Comparison with Table I shows that the drop of .625 inch required for the Oneida No. 2 buckwheat is practically all that a chimney 100 feet high is capable of producing under the conditions cited. Chimney draft is proportional to the height; hence it is evident that, with the temperature conditions previously stated, it would require a chimney $\frac{1.125}{.639} \times 100 = 176$ feet high to produce the draft necessary to burn the Eckley No. 3 buckwheat at the specified rate. In the ordinary plant of moderate size a chimney much over 100 feet high is the exception rather than the rule. Hence the inability to successfully burn the finer fuels and thereby secure the attendant commercial advantage.

But a pressure of 1.125 inches of water is well within that ordinarily furnished by a fan when introduced for producing mechanical draft. When the draft is produced by the forced system, it is customary to speed the fan so as to produce a pressure of 1 ounce per square inch, equivalent to 1.73 inches of water. In fact, the regular commercial types of steam fans are equipped with attached engines of sufficient power to drive the fans to this speed.

As the result of his extended experiments, Coxe asserted, with regard to a chimney, that "it is always very difficult, in fact almost impossible, to obtain sufficient blast to burn the smallest sizes of anthracite coal, which require a strong and concentrated draft." It therefore becomes one of the salient advantages of mechanical draft that it may be used either as an auxiliary to an existing chimney, or as an independent device to secure the successful combustion of fuel that will show increased commercial efficiency.

Many plants exist in which, owing to inadequate draft, it was impossible to keep up steam with anything short of a high-grade

TABLE II

DRAFT CONDITIONS WITH COXE STOKER

Items.	Size of Coal.		
	Buckwheat.	Buckwheat.	Rice.
Pressure in igniting compartment, inches of water	0.14	0.25	0.44
Pressure in burning compartment, inches of water	0.31	0.56	0.89
Pressure in burning-down compartment, inches of water	0.24	0.49	0.73
Pressure in burning-out compartment, inches of water	0.17	0.42	0.67
Pressure of blast of air, average, inches of water	0.24	0.43	0.68
Vacuum in furnace, inches of water	0.10	0.15	0.24
Total furnace draft, inches of water	0.34	0.58	0.92
Vacuum in stack flue, inches of water	0.13	0.40	0.58
Total draft, inches of water	0.37	0.83	1.26
Pounds of dry coal per hour per square foot of grate	19.80	32.90	28.00

TABLE III

RESULTS OF TESTS OF PEA AND BUCKWHEAT COAL

Kind of Coal.	Rate of Combustion per Square Foot of Grate per Hour.	Pounds of Water Evaporated From and at 212° per Pound of Coal.	Air Pressure in Inches of Water.	Maximum Limit to Size of Coal in Inches.
Oneida pea coal	13.63	8.56	0.375	$\frac{7}{8}$
Oneida No. 1 buckwheat	13.58	7.94	0.500	$\frac{9}{16}$
Oneida No. 2 buckwheat	11.40	8.60	0.625	$\frac{3}{8}$
Oneida No. 3 buckwheat	11.34	8.65	1.040	$\frac{1}{4}$
Eckley No. 3 buckwheat	9.44	8.75	1.125	$\frac{3}{16}$

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bituminous coal, like Cumberland, but which, when equipped with mechanical draft, have shown ability to burn fuels costing far less, and have returned in annual savings amounts varying from five to ten times the original cost of mechanical-draft apparatus.

The effect of attempting to burn low-grade in place of high-grade fuels under identical conditions, is well illustrated by Table IV, covering results obtained by Barrus in a considerable number of tests.

TABLE IV

EFFECT OF QUALITY OF FUEL ON OUTPUT OF BOILER

Kind of Fuel.	Rated Horsepower of Boiler.					
	54	74	87	129	140	270
Cumberland	60.0	143.8	105.4		94.0	214.6
Anthracite, broken	53.9	105.5	84.0	192.3	103.8	196.1
Pea				149 2		
1 part screenings and 1 part Cumberland		95.1				
3 parts screenings and 1 part Cumberland						204.8
2 parts pea and dust and 1 part Cumberland	38.5		82.2		118.1	
44 parts pea and dust and 37 parts culm				157.1		

The decreased power indicated is largely due to a reduction in the rate of combustion, which rate might have been maintained if the necessary draft had been available. Against this reduction in output, which might have been avoided by the introduction of mechanical draft, there is to be offset the decreased cost of the fuel per horsepower. Of course, the heat value of the fuel is likely to decrease with its cost, as is also the evaporative efficiency.

In Table V are shown the results of tests, also by Barrus, on coals of similar character. These are arranged in the order of their evaporative efficiency, Cumberland standing at 100. The then ruling fuel costs are also given per ton and per 1,000 pounds of water evaporated. Commercially considered, it is evident that, although the evaporative efficiency of the Nova Scotia culm is only 76 per cent. of that of the Cumberland, its value as regards its cost of making steam is 56 per cent. greater than that of the Cumberland coal. Under such conditions, the only essential to securing this advantage is the means to burn the fuel, and this has already been pointed out.

The possible annual gross savings from burning cheaper fuel are presented in Table VI for a 1,000-horsepower plant, based on 312 days of 10 hours each, and indicating the savings that would result if a coal of any given cost and evaporative efficiency were substituted for one costing $4.00 per ton and evaporating 11 pounds of water from and at 212° per pound of coal. Under these conditions, the annual expenditure for fuel would be $19,568. Suppose that, instead of this coal, there is utilized a low-grade fuel evaporating only 8 pounds and costing, say,

TABLE V

RELATIVE EFFICIENCIES OF VARIOUS COALS

Kind of Coal.	Water Evaporated From and at 212° by 1 Lb. of Dry Coal.	Relative Efficiency in per Cent. Cumberland = 100.	Cost of Coal per Ton.	Fuel Cost of Evaporating 1,000 Lb. of Water From and at 212°.	Relative Efficiency in per Cent. Measured by Cost to Evaporate 1,000 Lb. Cumberland = 100.
Cumberland	11.04	100	$3 75	$0.1698	100
Anthracite, broken	9.79	89	4.50	0.2297	74
Anthracite, chestnut	9.40	85	5.00	0.2660	64
2 parts pea and dust and 1 part Cumberland	9.38	85	2.58	0.1375	123
2 parts pea and dust and 1 part culm	9.01	82	2.58	0.1432	119
Anthracite, pea	8.86	80	4.00	0.2259	75
Nova Scotia culm	8.42	76	2.00	0.1187	156

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$2.25 a ton. The gross saving would be, according to the table, $4,433 a year, an amount over four times greater than would have to be expended for an engine-driven fan of sufficient capacity to make possible the utilization of this fuel.

But there are other items concerned in the commercial efficiency of a given fuel, as indicated in the opening paragraph. The questions of interest, rent, taxes, and insurance have already been discussed in a previous article on this subject, wherein it was shown that a mechanical-draft plant could be installed for from 20 to about 40 per cent. of the cost of a brick chimney of equal capacity. This preponderance of advantage in first cost is sufficient to offset any increased expense on account of depreciation and repairs on a mechanical-draft plant, which will not exceed those on the other elements of a steam-generating plant.

The cost of the water required for the production of steam may be considered constant with different grades of fuel, and hence will not enter into a comparison of costs.

The labor incidental to burning low-grade fuel is naturally greater than when better fuel is employed, because of the greater amount of fuel to be burned in order to secure a given result. Whether this will call for additional expense in a hand-fired boiler plant will, of course, depend on the amount of labor previously performed by each fireman. It is frequently the case, however, that a plant burning high-grade fuel is a little too much for, say, two men to handle, while not enough to keep three men well employed; nevertheless, it is necessary to employ three men. Under such conditions, the substitution of low-grade fuel would not call for an extra expenditure for labor.

But in the removal of ashes to a considerable distance (as is frequently necessary), the lower grade fuel, because of its greater proportion of ash, may call for extra labor expenditures, which should be figured as an offset against the gross saving.

In the matter of comparison, the cost of the fuel in all cases should be taken as that of delivery at the boilers, not merely its cost at the cars—possibly at some distance. It costs practically just as much per ton to handle one grade of fuel as another; hence the kind of which the largest amount is required to evaporate a given amount of water is the one that will cost the most in the matter of handling. Hence, the necessity of basing all comparisons on identical conditions.

In a careful consideration of operating expense with mechanical draft, there must also enter, as a matter of prime importance, the cost of operating the fan. Actually, this is almost infinitesimal as compared with the heat expenditure incident to the action of a chimney in producing the same draft. But the loss of heat, which is a necessary part of the action of a chimney, and which frequently represents from 20 to 30 per cent. of the value of fuel burned, can only be decreased by the introduction of some device in a sense apart from the fan. The fan itself, as a means of draft production, does not require for its action that the gases should have a temperature above that of the atmosphere. In other words, it presents the opportunity for the utilization of a considerable portion of the heat wasted by the chimney, and a fair proportion of this saving must therefore be credited to mechanical draft.

But there are many plants where economizers or other forms of heat abstracters are not or cannot be introduced. The actual

TABLE VI

ANNUAL SAVINGS RESULTING FROM BURNING CHEAPER FUEL IN 1,000-HORSEPOWER BOILER PLANT

Water Evap. From and at 212° per Lb. of Coal.	Cost per Ton.														
	$0.50	$0.75	$1.00	$1.25	$1.50	$1.75	$2.00	$2.25	$2.50	$2.75	$3.00	$3.25	$3.50	$3.75	$4.00
11.00											4,892	3,669	2,446	1,223	0000
10.50										5,474	4,198	2,912	1,680	349	
10.00									6,115	4,770	3,424	2,079	734		
9.50							8,240	6,823	5,407	3,991	2,575	1,159			
9.00						9,105	7,610	6,115	4,621	3,126	1,631	136			
8.50					10,074	8,491	6,909	5,326	3,743	2,160	578				
8.00				11,180	9,478	7,797	6,115	4,433	2,752	1,070					
7.50			12,393	10,599	8,805	7,012	5,218	3,424	1,630						
7.00	15,724	13,808	11,881	9,959	8,037	6,115	4,193	2,272	350						

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cost of operating the fan must then be deducted from the saving shown by reduction in the cost of fuel. In most plants, the exhaust steam from the fan engine can be utilized, and the actual expense of operation reduced to a very small quantity—at the utmost, not over 10 to 20 per cent. of the value of the steam supplied to the engine.

When the exhaust cannot be utilized, all steam supplied to the fan engine becomes a direct charge against this means of draft production. In a plant of 1,000 horsepower, as previously chosen for the basis of tabulated comparisons, the fuel expenditure for operating the fan would not, under good conditions, exceed 1½ per cent. of the total amount of fuel burned. Even with the most expensive fuel, calling for an annual expenditure of $19,568, the cost of fan operation would, therefore, be only $293.52. With a lower grade fuel, it would have been less. Such an expenditure for operating expense still leaves the handsome amount of $4,433.00 — $293.52 = $4,139.48 to be credited to the charge in fuel. Even an increased cost of handling the fuel and the ashes cannot reduce this amount to such an extent as to prevent the showing of an ample return.

In many plants where the demand for steam is variable and the power of the chimney to meet sudden demands is limited, it is necessary to run several boilers at low capacity during a portion of the time, in order to be able to meet the sudden requirements. As a consequence, the boilers may, for a considerable time, run at low efficiency, or what is more, a larger number of boilers will be required than would be necessary if the draft, and consequently the rate of combustion, could be instantly and materially increased. This latter arrangement, with its attendant advantages, is possible when mechanical draft is employed. It then becomes possible to increase instantaneously both the intensity of draft and the volume of air. The load can be picked up at once and steam rapidly generated during the period of excessive demand. In its effect on the operating expense, as represented by the fixed charges on the large boiler plant otherwise necessary, mechanical draft may thus show a material saving.

This is nowhere better exemplified than in marine practice, particularly in the naval marine, where the reserve capacity required for maximum speed may be stored in small, light, and rapidly running fans, instead of ponderous boilers filled with water, which may only be used at intervals. In the merchant marine, this arrangement increases the earning power of the vessel by decreasing the space required for boilers, and, consequently, increasing the cargo-carrying capacity.

The preceding discussion has had relation principally to the quantitative elements of the operating expense; that is, to those that can actually be measured in given quantities, as in fuel, money, etc. But there are also features of mechanical draft that can only be measured qualitatively in their relation to other methods. That is to say, these features possess certain advantages or disadvantages that are to be measured primarily as conveniences or inconveniences, which have, in a sense, no money value, but which, nevertheless, are important in the decision regarding relative merits. Such, for instance, is the feature of simplicity of control. The chimney, so far as the draft is concerned, is brought under the control of the damper regulator. But with the same temperature of the gases, any change in the position of the damper simply affects the volume of gases passing through, but does not regulate the intensity of the draft that is so essential in the securing of higher combustion rates and a greater output. The fan, however, may be as readily controlled as regards draft, but possesses the further and more important advantage, already pointed out, i. e., that the intensity of the draft varies coincidently with the volume of the gases passing through the fan.

A further convenience of the fan consists in its adaptability. It does not require heavy foundations, it may be placed on the ground or overhead, according to requirements, and may be employed either for forced or induced draft. Being constructed of steel plate, it may be built of almost any shape to accommodate the available space, and, being comparatively light, it is readily portable, and hence of value as an asset, where a chimney, being practically immovable, possesses a value only so long as it stands just where it is wanted.

Increased draft over the natural capacity of a chimney can only be secured by increasing its height at considerable expense. A change of pulleys, or of engine, or even of the cut-off of the engine is frequently all that is necessary with mechanical draft. All such features, in so far as they can be measured at their true value, must, therefore, enter into a fair consideration of the influence of mechanical draft on the operating expense of a steam-boiler plant.

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THE APPROACHING TOTAL SOLAR ECLIPSE

Ernest K. Roden

A Total Eclipse of the Sun to Take Place May 28—Positions Along the Path of Totality—Solar Prominences Visible to the Naked Eye

OF ALL astronomical phenomena, few are so striking to the imagination as a total eclipse of the sun. At the predicted hour, the brilliant disk of the sun becomes slightly indented at its western edge, and a black segment is seen slowly advancing, gradually obscuring the luminous surface until nothing but a faint pink-colored arc of the radiant day-star remains. Daylight rapidly diminishes and is replaced by a sinister gleam that has a curious effect on the beholder; everything puts on a dull and gloomy appearance, as when night is approaching, while the sky changes its pure azure for a livid, grayish color. When the totality of the eclipse is reached and the last ray of daylight dies out, a darkness as profound as it is sudden spreads all around, reducing the whole of nature to astonishment and silence. The stars begin to shine; the temperature decreases, while the humidity of the atmosphere is augmented; animals appear greatly alarmed, the dog runs for shelter, the birds cease their singing, and the hen covers her chicks with her wings. In place of the sun appears a black disk surrounded by a reddish crown, from which rose-colored flames seem to issue. After two or three minutes, however, the spectacle is at an end. The moon, which is the cause of all this disturbance, appears to slacken her grip, and Old Sol is again permitted to cover his protégé, the earth, with streamers of fertilizing rays; daylight once more returns, and a feeling of relief, coupled with admiration, is evidenced everywhere.

Such, in substance, are the circumstances attending a total eclipse of the sun; and similar conditions, perhaps with slight variations, will in all probability predominate during the total solar eclipse that takes place on the 28th of the present month.

Eclipses of the sun, we all know, are caused by the interposition of the moon between the earth and sun, which necessarily hides a large or small portion of the sun from view. This is very clearly illustrated in Fig. 1, where the black spot represents the moon's shadow falling on the earth, causing a total eclipse of the sun at that particular place. The dark shadow, it will be noticed, is conical. The less shaded region, exterior to the limit of the shadow, is termed the *penumbra*. To persons situated within this region the sun will appear partially eclipsed. As a general rule, the shadow cast by the moon travels along the earth's surface in an easterly direction; as a result, more westerly observers will see the eclipse earlier than those east of them. The accompanying map (Fig. 4) shows the path of totality *A B* and also indicates the limits of the eclipse. This totality, it will be seen, commences in the Pacific Ocean at a point southwest of Cape San Lucas, Lower California; moving in a northeasterly direction, it enters Mexico about midway between Mazatlan and the mouth of the San Pedro River, passing almost directly over Gonzales, Mexico, and Edinburg, Tex., and then enters the Gulf of Mexico about 40 miles north of Brownsville, Tex. After traversing the northwest

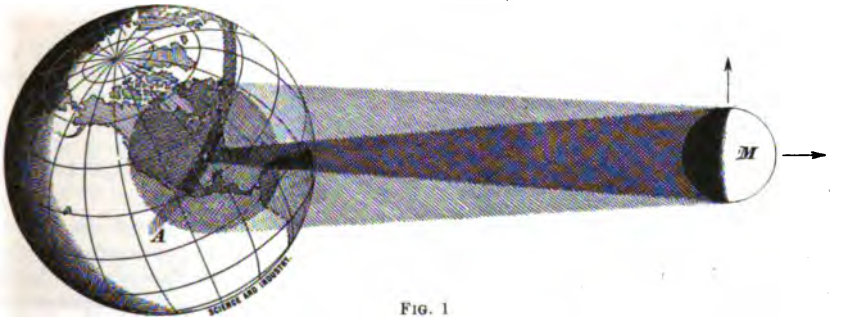

Fig. 1

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corner of the Gulf it passes over Morgan City and New Orleans, La.; Mobile and Union Springs, Ala.; Columbus and Greensboro, Ga.; New Market and Chester, S. C.; Monroe and Winton, N. C.; Suffolk,

FIG. 2.—AS THE ECLIPSE WILL APPEAR AT NEW ORLEANS, LA.

Newport News, and Cape Henry, Va. It then enters the Atlantic Ocean, still moving in a northeasterly direction until it arrives at or near latitude 45° N, when it gradually changes its direction to southeast, passing through Portugal and Spain, and enters the

FIG. 3.—AS THE ECLIPSE WILL APPEAR AT SCRANTON, PA.

Mediterranean Sea near the mouth of the river Segura; after crossing the Mediterranean, it passes over the city of Algiers, skirts the coast of Tripoli, and terminates at sunset in Upper Egypt. The local times and conditions at certain points along the path of totality are as follows:

POSITION CLOSE TO NEW ORLEANS, LA.
(Lat. 30° 4′ N, Long. 90° 6′ W.)

	Central Standard Mean Time.
Eclipse begins	May 28, $6^h\ 26^m\ 37^s$ A. M.
Totality begins	May 28, $7^h\ 30^m\ 6^s$ A. M.
Totality ends	May 28, $7^h\ 31^m\ 24^s$ A. M.
Eclipse ends	May 28, $8^h\ 43^m\ 34^s$ A. M.

Duration of totality = $1^m\ 17.8^s$.

POSITION NEAR UNION POINT, GA.
(Lat. 33° 29′ N, Long. 83° 5′ W.)

	Central Standard Mean Time.
Eclipse begins	May 28, $6^h\ 32^m\ 45^s$ A. M.
Totality begins	May 28, $7^h\ 40^m\ 12^s$ A. M.
Totality ends	May 28, $7^h\ 41^m\ 44^s$ A. M.
Eclipse ends	May 28, $8^h\ 58^m\ 36^s$ A. M.

Duration of totality = $1^m\ 32^s$.

POSITION SOUTH OF CAPE HENRY, VA.
(Lat. 36° 42′ N, Long. 76° 5′ W.)

	Eastern Standard Mean Time.
Eclipse begins	May 28, $7^h\ 40^m\ 55^s$ A. M.
Totality begins	May 28, $8^h\ 52^m\ 27^s$ A. M.
Totality ends	May 28, $8^h\ 54^m\ 13^s$ A. M.
Eclipse ends	May 28, $10^h\ 15^m\ 22^s$ A. M.

Duration of totality = $1^m\ 45.6^s$.

POSITION SOUTHWEST OF TALAVERA DE LA REINA, SPAIN.
(Lat. 39° 47′ N, Long. 5° 10′ W.)

	Greenwich Mean Time.
Eclipse begins	May 28, $2^h\ 49^m\ 58^s$ P. M.
Totality begins	May 28, $4^h\ 6^m\ 42^s$ P. M.
Totality ends	May 28, $4^h\ 8^m\ 9^s$ P. M.
Eclipse ends	May 28, $5^h\ 16^m\ 18^s$ P. M.

Duration of totality = $1^m\ 27.4^s$.

In all of these places named, the eclipse will be total, the general appearance of which is shown in Fig. 2; at other places within the limit of the penumbra the eclipse is partial. At Washington, D. C., for instance, about seven-eighths of the solar disk will be eclipsed. At Scranton, Pa., the maximum of darkness is reached at $8^h\ 54^m$ A. M. Eastern Standard mean time (or the time that our ordinary clocks and timepieces are supposed to indicate).

The duration of a total eclipse is generally very short; under any circumstances it cannot exceed $7^m\ 38^s$. The greatest duration of an eclipse recorded in the annals of astronomy is one that occurred August 17, 1868, and which was visible in India; the totality of this eclipse lasted in some places nearly six minutes.

Although subject to considerable variations in different eclipses, the darkness is never so great as might be expected from the complete obscuration of our luminary. The

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reason for this is that the part of our atmosphere that is still exposed to the direct rays of the sun reflects some of that light to us, which thus diminishes the darkness resulting from the disappearance of the sun. Usually, the darkness is sufficient to prevent the reading of common print.

An interesting fact connected with solar eclipses is the luminous corona and brilliant prominences that encircle the edge of the sun. These prominences were first observed during the total eclipse on July 8, 1842; but they have been found to be constant attendants of the sun, and methods have been invented for rendering them visible at any time, without the interposition of the moon. The spectroscope, which is the instrument used for this purpose, shows them to consist mainly of hydrogen gas in an incandescent state, and a comparatively narrow belt of the same color and substance runs round the whole circumference of the sun. The prominences are sometimes seen to shoot up like flames in wild, fantastic shapes, with incredible velocity, and to the height of tens of thousands of miles. During the totality of an eclipse the prominences, or *protuberances*, as they are called, are seen without the aid of the spectroscope (using a slightly smoked glass), and appear then in their natural color, which, although somewhat varying in their different parts, is, on the whole, pinkish and similar to that of peach blossoms; yet it is mixed here and there with delicate prismatic hues, among which the pink and straw colors predominate.

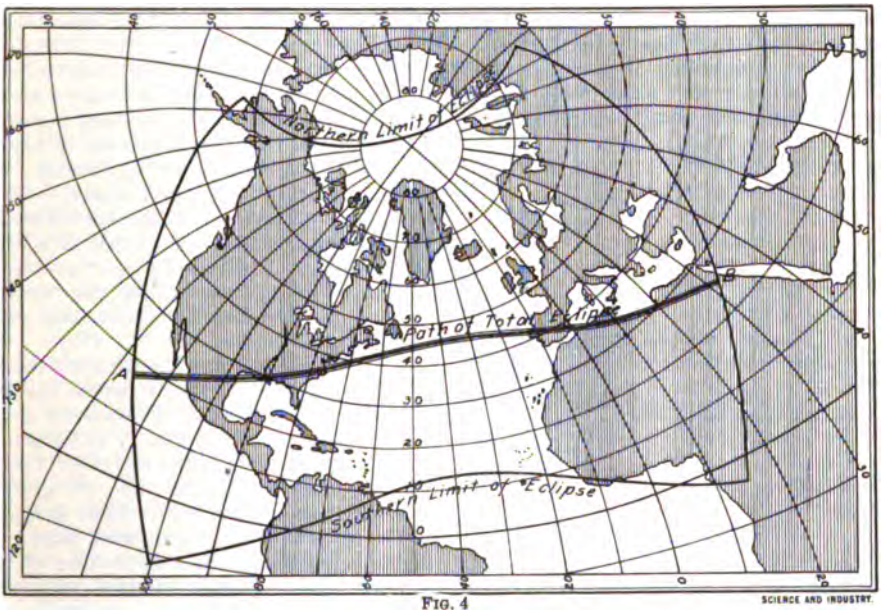

FIG. 4

Altogether, the eclipse of May 28 next will be one of great interest, not only to men of science, who will line the path of totality from beginning to end, but to everybody that is impressed by the grandeur of natural phenomena.

SPEED OF TELEGRAPHING

Samson

IN A telegraph tournament held in New York, in May, 1898, the winner, W. M. Gibson, in the championship 5-minute sending contest, transmitted 254 words with only one error, and his Morse was said by the judges to be perfect. The highest recorded speed of legible telegraphy in which the Morse code was used was made in a previous contest, in which 265 words were sent in 5 minutes. An expert operator can send 35 to 45 words a minute, but a steady working rate of 25 to 30 is regarded as good.

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TELLTALES FOR CIRCUIT-BREAKERS

TELLTALES FOR GENERAL ELECTRIC CIRCUIT-BREAKER—TELLTALE FOR WESTINGHOUSE CIRCUIT-BREAKER—STEAM-WHISTLE ATTACHMENT

IN STREET-RAILWAY power stations it is often desirable to have some telltale arrangement attached to the circuit-breakers, so that the attention of the station attendant will at once be attracted when any breaker flies out. This is especially necessary in cases where there are a large number of circuit-breakers on one board, for the reason that in such a case one or more breakers might remain out for some time before being noticed. In small stations, such

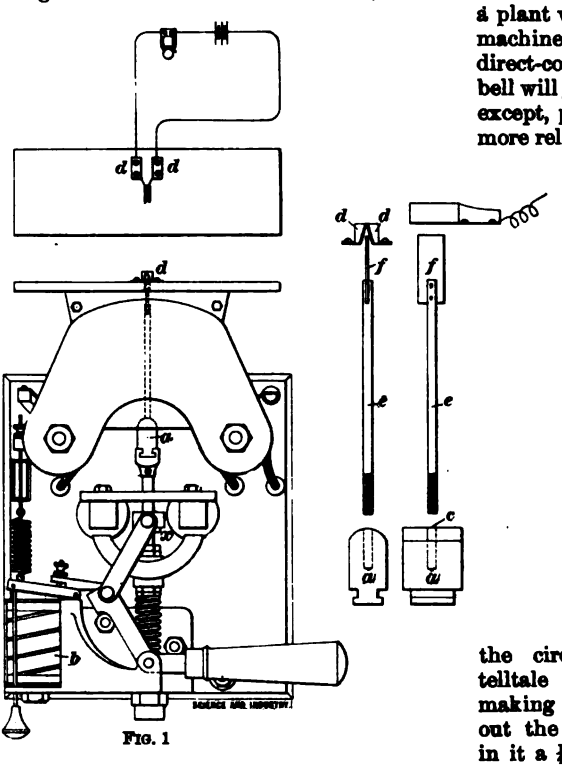

FIG. 1

arrangements are not so necessary, as there are only one or two breakers, and the attendant will at once see when one of them goes off. In many cases, however, a circuit telltale is of use even in a small station, especially if the engineer in charge has to spend part of his time in the boiler room. Nearly every different station has its particular device for accomplishing this purpose, each engineer exercising his own ingenuity in the matter, and the purpose of this article is to give a few of the methods in more common use, as applied to one or two standard types of circuit-breakers.

The device used to give the signal is generally arranged to operate an electric bell, an incandescent lamp, or a small steam whistle. The first method of operating a bell is the most common, although the last method of operating a small steam whistle has been used with good results. A steam whistle is more apt to make itself heard in a plant where there are a number of belted machines in operation; but in stations with direct-connected machinery, a good electric bell will give fully as good results as a whistle, except, perhaps, that the whistle is a little more reliable. The lighting up of an incandescent lamp above the circuit-breaker has also been used with good results.

We will first describe an arrangement suitable for a General Electric circuit-breaker. This scheme is one submitted by Mr. P. E. Mitchell, of New Orleans, for the "Useful Ideas" columns, but we give it here, along with other arrangements, to be described later.

Fig. 1 shows an outline of the circuit-breaker referred to. It is of the well-known General Electric switchboard type, and the device for operating the telltale is attached to the copper block *a*, which makes connection between the terminals of the magnetic blow-out arrangement. In the position shown, the circuit-breaker is "out," and the telltale is in operation. The method of making the attachment is as follows: Take out the copper block *a* and drill and tap in it a ¼-inch hole *c*. It needs an experienced hand to tap out holes in pure copper, as the metal is so tough that the tap is liable to break off. In order to avoid this trouble, a ⅜-inch hole may be drilled about 1 inch deep, and then filled with solder. The solder may then be drilled with a $\frac{7}{16}$-inch hole and tapped with a ¼-inch tap without difficulty. Next, take a round fiber rod *e*, about 6 inches long and ¼ inch diameter, and cut a thread on one end so that it will screw into the block *a*. Cut a slit $\frac{1}{16}$ inch

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wide in the end of this, and fasten in, by means of small rivets or pins, a flat piece of fiber *f*. This fiber should be about 1½ in. × 2 in., and should be glued in place as well as riveted. Two springs *d*, *d* are then mounted on the fiber top of the circuit-breaker in such a way as to project over the opening and come in line with the fiber piece *f*. The springs are made of No. 20 spring brass, and may be fastened to the fiber-top piece by round-headed brass wood screws. These springs must be so arranged that when the circuit-breaker is in, the flat piece *f* will be forced up between them, thus holding them apart. When the breaker goes out the fiber piece drops down, thus allowing the springs to make contact and ring an electric bell. The rod should be made of such length that the flat piece will never entirely move out from between the brass clips; it should merely drop down far enough to allow the tips to come together.

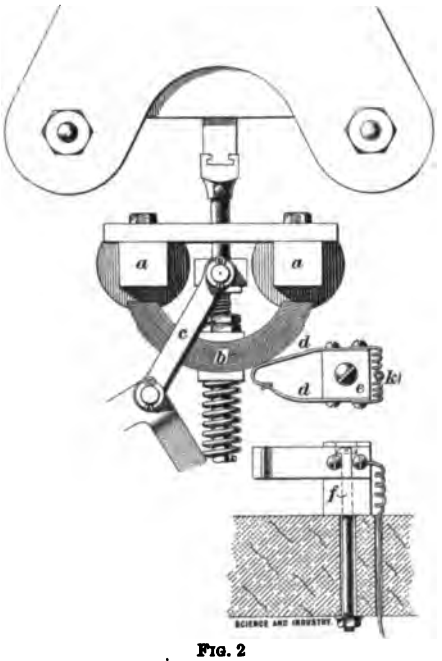

FIG. 2

This arrangement works very well in practice, but it appears as if there would be danger of the fiber rod becoming burnt through in time. It passes up between the contacts where the arc is formed, and, although the arc is extinguished very quickly, there might be danger of the fiber rod being charred by the arc.

Fig. 2 shows another method for attaching a telltale to this type of breaker. This is easier to apply than the arrangement shown in Fig. 1, and there is no danger of any part being burnt. The figure shows only those parts of the breaker that are necessary to bring out the method of attachment. *a*, *a* are the two copper contact studs of the circuit-breaker; *b* is the laminated copper contact that presses against studs *a*, *a*; *c* is one of the links of the togglejoint. The method of attaching the contacts for the bell circuit is shown at *k*; *e* is a small square piece of fiber or hard wood, neatly cut out and blackened to match the slate base of the circuit-breaker. This block may be fastened in place by means of a round-headed stone bolt *f*, passing through the slate base. If care is taken, the slate may be tapped out and a machine screw used for holding block *e* in place; this is desirable because it admits of *e* being attached without taking down the breaker. The bases on these circuit-breakers are usually about 2 inches thick, and, if a machine screw is used, it should be tapped

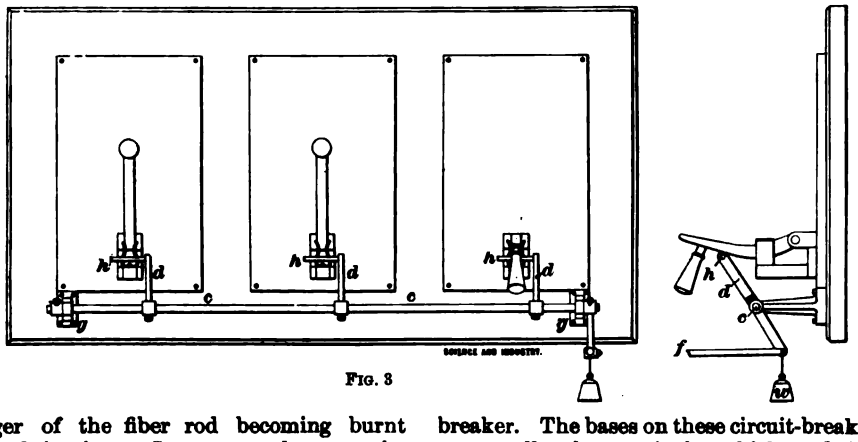

FIG. 3

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into the base at least 1 inch. Two springs *d*, *d*, shaped about as shown, are mounted on the block so that they will just make contact with each other when the laminated contact *b* is at its lowest position. Care should be taken to place the block so that it will not be too high; otherwise, when *b* flies down, the springs will be struck a severe blow, and will be bent to such an extent that they will soon break off. The action of the arrangement is obvious; when the breaker flies out, the springs *d*, *d* are pressed together, thus ringing an electric bell or lighting an incandescent lamp, as the case may be. The wires leading to the signal device may be carried down through the slate, as shown, or they may be carried up across the face of the breaker, and over the top of the board.

It is a comparatively simple matter to place a signal attachment on a Westinghouse circuit-breaker. This breaker, which is familiar to most station men, is shown in Fig. 4. It has two brass clips that catch the switch lever when it is thrown out. In many stations, these clips are utilized as the contacts for the alarm circuit. These may be insulated by using fiber, and thus made to form the terminals. Both clips should be insulated so that the bell circuit will not be in connection with the trolley circuit when the breaker is closed. When the breaker flies out, contact is made between the clips by the brass arm and the bell or lamp operated.

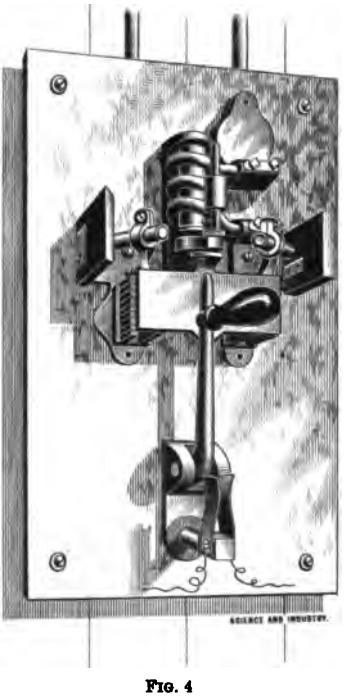

FIG. 4

Fig. 3 shows an arrangement that has been successfully used with Westinghouse breakers, in which a small steam whistle is sounded whenever a breaker goes out. The sketch is intended to show the general scheme only, because, in most cases, the arrangement here shown would be modified more or less to meet special conditions. A small steel shaft *c* runs across the switchboard directly under the row of circuit-breakers. This shaft is supported at intervals of 3 or 4 feet in bearings *g*. At each breaker an arm *d* is attached, and this arm carries a pin *h* that projects under the breaker arm. When the breaker flies out, this arm is depressed, thus turning the shaft with lever *d*, and pulling the rod *f*. In order to make sure that the lever *h* will swing back when the breaker is thrown in, a weight *w* may be attached to the end of *d*, or a spiral spring may be arranged to accomplish the same purpose. The rod *f* may be made to operate a small steam whistle directly, or open a valve in a steam pipe so as to operate a whistle at some point distant from the switchboard. The fittings necessary for carrying this out in any special case will readily suggest themselves to the engineer.

This method is specially applicable in cases where there is a long row of circuit-breakers or feeder panels. One shaft can be run the whole length of the board, and thus be made to serve for all the breakers. The cost per breaker is thus made comparatively small, and, if the arrangement is properly put up, it is not likely to get out of order. Some such device could doubtless be used in connection with the General Electric breaker, although the construction of this breaker is such that it does not admit of its being carried out as easily. Nearly every station engineer has his own arrangement for giving circuit-breaker signals, and it is surprising to one that visits several different stations to note the number of different schemes that have been devised. Possibly many of them are even simpler than those here given, but the foregoing may be taken as some arrangements that have been found useful for this purpose.

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THE HYGIENE OF SWEEPING

T. M. Johnson

REMOVAL OF DIRT FROM THE HOUSE—CLEAN DIRT AND DIRTY DIRT—HOW DIRT IS RAISED WITH A BROOM—THE HYGIENIC VALUE OF A CARPET SWEEPER

HYGIENE is the name of that department of science which relates to the preservation of health; it embraces everything directly or indirectly connected with physical well-being, except the direct use of medicines and medical treatment. Hygiene is really a far-reaching science; it does not confine itself to the precincts of the home—in fact, it is an important matter wherever human beings exist. However, let us be satisfied at present with a few simple yet timely remarks on hygiene in the home; let us digest some plain facts that materially affect the wholesome or unwholesome character of a home. Although hygiene, as applied to the individual, is a most important factor of health, happiness, and longevity, and the application of hygienic principles in cases of sickness is also a matter worthy of careful attention, we will for the present say nothing about these subdivisions, but confine our remarks to hygiene as applied to the dwelling house and its vicinity.

DRIVING THE DUST IN THREE DIRECTIONS — ONWARD, UPWARD, AND DOWNWARD—INHALING IT AS SHE GOES

The greatest protection against disease is cleanliness. It exceeds all others, and is the measure we propose to advocate in this article. Cleanliness really is the great aim of all hygienic regulations. There is a very old saying that "Cleanliness is next to godliness," and no one questions the truth of it. Even ministers have quoted this expression in the pulpit, which shows that they also recognize the close alliance between the hygiene of the body and the hygiene of the soul. In fact, it would be strange if it were otherwise, for it seems rational to suppose that any person that respects the soul will endeavor to keep a clean earthly tabernacle around it.

But let us quit moralizing and confine ourselves to practical facts. What is cleanliness? Cleanliness, in the sense intended in this article, simply means absolute freedom from noxious dirt. Now, there are different kinds of dirt; there is what some people are pleased to term "clean dirt," and there is foul dirt. But whether any particular dirt is clean or foul cannot be determined until it has been chemically analyzed and microscopically examined. Even then there is doubt, for dirt is simply matter out of place. Dirt is dirt whether it is simply unpleasant but harmless, or whether it is dangerous on account of being poisonous or on account of the presence of living disease germs, and it should be placed where it belongs. It is true that there is a great deal of dirt that, although unpleasant, is quite harmless, at least as far as any tangible injury to health is concerned. Indeed, an immense amount of dirt in the form of dust may even be inhaled if it is free from poisonous or other injurious substances. But there is also an actively dangerous dust — a dust that carries with it not only poisonous substances but also disease germs of the most virulent type. However, in the absence of an analysis, we can only guess as to the nature of any dust.

One of the most eminent authorities on the dust question says: "In most cases where there is *visible* dust and dirt, there is also actively dangerous dirt, that is, dirt that is sometimes not visible, but that contains active poisons. Therefore, all visible dirt becomes objectionable." By dirt that is not visible, this authority means the dirt that cannot be detected except by the aid of the microscope. This, he claims, is the most dangerous enemy of the human race. Bacteria is an invisible menace that must be guarded against at all times. Millions of them may be present in a room, or on a small

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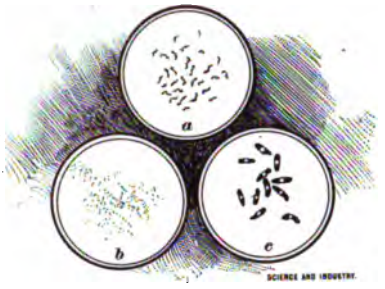
part of the surface of something in a room, and we may even have countless numbers served in a cold lunch without knowing it, since they cannot be recognized by taste,



BACTERIA HIGHLY MAGNIFIED

Look steadily at this for 30 seconds. It will impress you with the necessity for real cleanliness. a and b represent bacteria found in infected suppurating wounds. c are disease-producing bacteria containing spores. The body of the bacillus is shown black and the spores white.

smell, or feeling. The paper on which this article was written may have been so infected with bacteria as to shatter the nervous system of the writer had he made a microscopic examination of it. However, it is not the writer's intention to frighten people from

THIS REDUCES THE AMOUNT OF FLOATING DUST TO A MINIMUM

their meals or scribes from their manuscripts, but simply to show how ignorant we are of the presence of bacteria even in the things that receive the closest scrutiny.

The only safeguard in the home is cleanliness—*real cleanliness*—and, in showing the necessity of it, we will try to show the difference between real and false cleanliness. A certain woman, weary, worn, and sad, spends most of her time stirring up dust in her house, thus keeping the atmosphere of her home almost constantly charged with flocculent solid matter to which germs may or may not be clinging. This part of her appointed task is known as sweeping and dusting, or "cleaning house." She takes a broom and works it vigorously over the carpet, displacing dust and dirt in three ways. Part of it works down through the interstices of the carpet and remains there until the carpet is lifted, or, indeed, if the carpet is closely woven on the under side, the upper soft fabric will become so thoroughly clogged with dust that nothing but a good beating or washing will remove it. Another part of the dirt, the larger particles, is swished with measured strokes to the point where the accumulation is gathered up or swept out after it has been separated from the finer particles. Most women take a delight in removing this part of the household dirt in a dust pan, for it is visible, and, if allowed to remain long, would soon discolor the carpet. Many of them pick up a surprisingly large quantity too, for they have the knack of *throwing* it forward and thus pushing the least possible amount into the carpet. But some women, and I think it safe to say *all* men, have the unhappy faculty of sweeping a dirty carpet without taking a teaspoonful of dirt from it; on the contrary, they rub it in. Men are particularly noted for "rubbing it in." The third part of the dirt disturbed by the house cleaner's broom is wafted upwards in air-currents produced by the motion of the broom. This is the fine flocculent dust that is almost invisible in a dingy room, but is very noticeable in a well-lighted apartment. In sweeping, as in all other household work, except chopping wood, bringing up coal,

FEATHER DUSTER

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and carrying out ashes, women are superior to men. Expert housewives can sweep an ordinary room with so little commotion that the floating dust does not become visible; but some women and most men sweep so viciously that the dust rises in dense clouds and finally settles on the walls, furniture, and draperies of the room.

To thoroughly and effectively remove dust and dirt from carpeted floors, it is necessary to lift the carpets and shake them outdoors. This is an argument in favor of mats, because they are not tacked down and can be lifted easily. The floor under the mats should have close joints and an oil finish. Open joints in the floors are receptacles for dirt, and they cannot be cleaned out. The dust on the closely jointed oiled surface can easily be removed with a damp mop, and no dust will rise to vitiate the air or settle on the furnishings. This method is not open to the hygienic objections raised in the case of the ordinary floor and tacked carpets.

CHURNING UP THE DUST AGAIN WITH THAT DESPICABLE FEATHER DUSTER

The dirtiest part of a house is the floor, for dirt is brought in on boots and shoes and tracked through the house. The furnishings gather the dirt almost entirely from the air in the house, and, to prevent this, it is necessary to keep the dirt from rising. This can be accomplished in the case of an impervious floor such as oilcloth, linoleum, oiled wood, rubber, flagstones, marble, tile, etc., by the use of a damp mop. Linoleum is a thoroughly hygienic floor covering, and is especially desirable for kitchens, pantries, dining rooms, bathrooms, and halls and passages, particularly if there are children around; for it is a rare thing for them to wipe their muddy feet when they come into the house.

Notwithstanding these facts, many a floor that ought to be covered with linoleum is covered with carpet, and many a tired mother struggles along in the vain hope of "keeping down" the dirt in a beautifully carpeted sitting room. In such cases, the best thing to sweep with is a modern carpet sweeper of approved make. This picks up most of the dirt, throws it into a receiving chamber inside the sweeper, and reduces the amount of floating dust to a minimum. Of course, some dust rises even with this ingenious device, but it is very small indeed when compared with the amount raised by the broom. After the floor has been vigorously swept by a broom and the clouds of dust have had time to settle, ordinary housewives commence to churn up the dust again with that despicable feather duster. The object of dusting should be to lift the dust, carry it outdoors, and there shake it off. But turkey feathers are not made for that purpose. They thoroughly scatter the dust, however, and it settles elsewhere. The result of dusting in this way, therefore, is not the removal of the obnoxious matter, but simply a shifting of its position to places where it cannot be seen. True, the windows and doors may all be open while this dusting is going on, and some of the dust may be carried out in the air-currents, but it is a fact that the feather duster is very inefficient in removing dust and dirt, and is an intolerable nuisance. Anything that will lift and remove dust, such as cheese cloth, should be used instead.

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COMPOUND ENGINES

John A. Grening

THE THERMAL EFFICIENCY OF A STEAM ENGINE—ECONOMY OF A STEAM ENGINE—INFLUENCE OF CYLINDER CONDENSATION ON ECONOMY—MECHANICAL ADVANTAGES

WHILE nearly every engineer is familiar with the statement that a compound engine is more economical than a simple expansive engine, there are many of the younger generation of steam engineers that do not know the why and the wherefore of the superior economy of the compound engine. We shall try to present here, in a short, concise way, as much of the theory of compounding engines as will enable one not familiar with it to see for himself, and to explain to others, why compounding is resorted to, and wherein it is superior to the simple expansive engine.

As some knowledge of the science of thermodynamics is essential to a clear understanding of what follows, enough of it is given here to make the latter part of the article clear to those that have never studied the subject.

According to the modern theory of heat that is now generally accepted as correct, heat is a rapid vibratory motion of the molecules of which a body is composed. According to this theory, the degree of heat of a body depends on the rapidity of vibration of the molecules; that is, the more rapid the vibration, the hotter the body; conversely, the slower the vibration, the colder the body. Furthermore, according to the first law of thermodynamics, the truth of which has been proved experimentally, heat and work are mutually convertible; that is, heat may be converted into work, and vice versa.

Now, a steam engine is one form of a heat engine, in which steam is the agent by means of which heat is transformed into work. As each unit of heat is capable of doing a definite amount of work, it follows that if the temperature of a given quantity of steam is lowered, a definite quantity of useful work can be done, inasmuch as the lowering of the temperature means an abstraction of heat from the steam. In order, therefore, that all the heat energy stored up in a given quantity of steam may be transformed into work, it would be necessary to take from the steam all of its heat, that is, all of its molecular motion. In other words, its temperature would have to be lowered until its molecules were at rest. From various experiments, it is concluded that the temperature at which every body would be in that state, is about 460° below Fahrenheit zero, which point is called the *absolute zero* of temperature. Hence, the absolute temperature can be obtained by adding 460° to the temperature shown by a thermometer, when the temperature is above zero on the Fahrenheit scale. When the temperature is below zero, the absolute temperature can be obtained by subtracting the number of degrees it is below zero from 460. Thus, if the thermometer registers 40° above zero, the absolute temperature would be $460° + 40° = 500°$. If the thermometer indicates 15° below zero, the corresponding absolute temperature is $460° - 15° = 445°$.

As the abstraction of heat, and consequent proportional amount of work that may be done by it, when taking place in the cylinder of an ideal steam engine, involves a lowering of the temperature of the steam, it may be said that the work done under ideal conditions will be proportional to the fall of temperature. That is, the greater the fall of temperature, the more heat will be available for doing work; conversely, the less the fall of temperature, the less heat is at our disposal for conversion into work.

As the work that may be done by steam depends on the fall of temperature, it follows that the temperature range, i. e., the difference between the temperatures of the incoming and outgoing steam, if contrasted with the total energy contained in the entering steam, will be the measure of the thermal efficiency of an ideal steam engine.

Now, the total energy available for transformation into work is directly proportional to the absolute temperature of the entering steam; hence, we may say that in an ideal steam engine, or, in fact, any other ideal heat engine, the relation between the useful work that may be done and the total energy available is equal to the relation the temperature range bears to the absolute initial temperature. Then, as the ratio between the temperature range and the absolute initial temperature is the thermal efficiency, it follows from arithmetic that it may be expressed in per cent. by dividing 100 times

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the temperature range by the initial temperature. For instance, if by some means we could cool a quantity of steam from 600° absolute to zero absolute, the temperature range would be 600°, and the thermal efficiency would be $\frac{600 \times 100}{600} = 100$ per cent. Similarly, if the temperature of the entering steam is 800° absolute, and the temperature of the exhaust steam is 700°, the efficiency would be $\frac{(800 - 700) \times 100}{800} = 12.5$ per cent.

Having seen that the temperature range determines the efficiency, and that the greater the range the greater the efficiency, we can now examine the two ways in which the temperature range can be increased. We must either lower the temperature of the exhaust steam or raise the temperature of the entering steam. The temperature of the exhaust steam can only be lowered by adding a condenser, and the lowest temperature attainable in practice is about 562° absolute, corresponding to a vacuum of 28 inches in the condenser. This vacuum may be considered the best obtainable in ordinary practice.

Knowing the sharply defined limit below which the temperature cannot be lowered, we will now consider the other way of increasing the temperature range. As the temperature of the steam increases with the pressure, it is evident that by raising the steam pressure of the entering steam, and keeping the pressure of the exhaust steam as low as feasible, the temperature range is increased. Following out this idea, pressures have been raised from the 8 to 10 pounds carried in the time of Watt, to 225 pounds per square inch, and over.

In connection with this, it is well to bear in mind that, in an actual steam engine, high pressure in itself is not necessarily a measure of economy, neither is a great temperature range always the most economical condition obtainable in an actual engine. Practical considerations, many of which cannot be calculated with any great degree of accuracy, here enter into the problem. In an actual engine, it is not possible to transform all the heat abstracted into useful work, and it must, or rather should, be the aim to reduce the heat losses to the smallest quantity possible.

Referring again to an ideal steam engine, where it is assumed that all of the heat is transformed into useful work, the most obvious way of getting a large temperature range will be to use a high steam pressure and an early cut-off. But as soon as we try to do this in an actual single-cylinder engine (known technically as a simple expansive engine), we are confronted by practical difficulties, the chief one being the initial condensation of the entering high-pressure steam subsequent to the cooling of the cylinder walls by the exhaust steam. Let the temperature of the entering steam be 753° absolute, and the temperature of the exhaust steam 613° absolute. Then, the fall in temperature during expansion will be 753° − 613° = 140°. Now, the cylinder walls, especially in engines having a very slow piston speed and having the cylinder poorly covered, will cool off to nearly the temperature of the exhaust steam, and hence the incoming steam must give up part of its heat in order to heat the cylinder walls again. As a matter of course, the condensed steam represents nearly a total loss of heat. We say *nearly*, because owing to the fact that the cylinder walls do not cool *entirely* down to the temperature of the exhaust steam, some of the steam condensed on entering is evaporated again near the end of the stroke.

Suppose, now, that the temperature of the incoming steam is 842° absolute, and that the temperature of the exhaust steam is again 613°. We now have a temperature range of 842° − 613° = 229°. A little thought will show that with this enlarged temperature range, a good deal more initial condensation will occur in order to raise the temperature of the cylinder walls to 842° again. From this the conclusion may be drawn that increasing the range of temperature increases the loss due to cylinder condensation.

From the foregoing it can be inferred, and, in fact, is borne out in practice, that a high thermal efficiency, if calculated for an *actual* engine, does not necessarily mean that the engine will be economical. In practice, we want an engine to develop the greatest amount of power with the least expenditure of money, and as it costs money to produce steam, we may say the amount of steam consumed per horsepower per hour is the measure of the economy of the engine. Hence, it is seen that the terms "thermal efficiency" and "economy," when applied to an engine, while correlated are not synonymous—a fact that the steam engineer must well bear in mind.

Having seen that a high ratio of expansion, i. e., a high temperature range in a single cylinder, means a great initial condensation

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and subsequent loss in economy, let us see what the effect will be if the expansion of the steam takes place in successive stages in several cylinders through the same temperature range. Then, the total temperature range being the same, it is evident that the temperature range in each cylinder will only be a fraction of it, and the effect of this is to reduce the condensation loss considerably below that occurring in one cylinder having the same total temperature range. This fact has been established beyond doubt by numerous experiments, and has led successively to the adoption of compound engines, then triple-expansion engines, and lately quadruple-expansion engines.

We will now consider some facts showing the reason why a division of the temperature range between several cylinders tends to reduce cylinder condensation.

It takes an appreciable period of time to change the temperature of the cylinder walls from the temperature of the exhaust steam to that of the entering steam. In most cases, if not in all, the time during which the entering hotter steam is in contact with the cylinder walls is so short that the incoming steam cannot heat them to its own temperature. Likewise, the time during which the cylinder walls are in contact with the exhaust steam is usually so short that they do not cool entirely down to its final temperature. Consequently, the fluctuation of temperature of the cylinder walls is less than the temperature range of the incoming and exhaust steam.

It is a well-known fact that the *rate* at which heat passes from a hot body (the entering steam in this case) to a cold body (the cylinder walls in the case under consideration) depends on the difference in temperature between the two bodies. When the temperature difference is great, the rate of heat transmission is much larger proportionally than it would be if the temperature difference were small. In other words, the rate at which the transfer of heat takes place increases much faster than the temperature difference.

It follows from this principle, when the difference in temperature between that of the incoming steam and that of the cylinder walls, previously cooled by the exhaust, is small, that less heat in proportion to the temperature difference will be given up to reheat the cylinder walls than would be the case for a larger temperature difference. Similarly, if the temperature of the exhaust steam is but little below that of the cylinder walls, less heat in proportion to the temperature difference will be lost by the cylinder walls.

Now, by expanding steam successively in several cylinders, we not only decrease the temperature range in each cylinder, but also greatly decrease the fluctuation in temperature of the cylinder walls. Then, as the rate of heat transmission is proportionally much smaller for a small fluctuation of temperature, it follows that the sum of the condensation losses in the several cylinders will be smaller than the condensation loss occurring in a single cylinder having the same temperature range between the initial and final temperatures.

Another probable cause of reduction of cylinder condensation by compounding is that the steam condensed in the high-pressure cylinder, and reevaporated during the exhaust period, enters the low-pressure cylinder as *steam;* hence, the heat given up in the high-pressure cylinder by the entering steam in heating the cylinder walls is not a total loss, as would be the case if, instead of exhausting into a second cylinder, exhaust took place into the atmosphere or into a condenser.

It must not be inferred, however, that it was solely due to the reduction of cylinder condensation that compound engines have come in favor. There are certain mechanical advantages to be derived by their employment, which, undoubtedly, have contributed in a large measure to their adoption.

Referring now to a compound having cranks at a right angle, it can readily be shown that it will run more steadily than a single-cylinder engine having the same steam pressure and weight of flywheel. A triple-expansion engine with cranks at 120° to each other will run even steadier than the compound. Of course, the same steady running may be obtained by coupling two or more simple expansive engines to the cranks; but even if this is done, it can be shown that the two-crank compound is subject to much lighter strains than the two-crank two-cylinder simple expansive engine having the same power, initial pressure, and ratio of expansion. The same statement applies to triple-expansion engines as well. The parts being subjected to less strain, and also to less variation in strain, they may be made lighter in the compound and triple-expansion engines than is possible in a multiple-cylinder simple expansive engine.

The question will naturally arise: When is it advisable, for the sake of reduction of cylinder condensation, to use a compound

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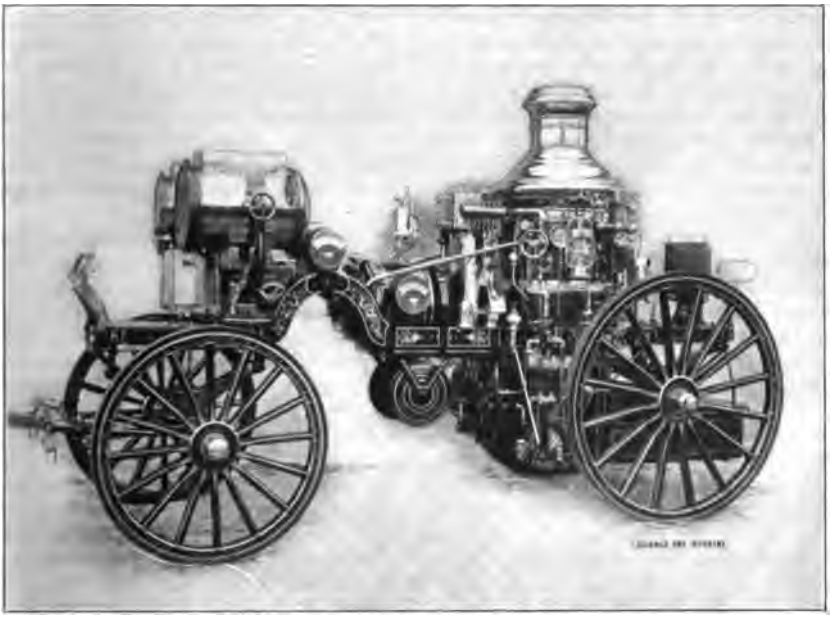
engine instead of a simple expansive engine? Unfortunately, no definite answer can be given to this question, as the answer must take in account all of the conditions, which will vary for each case. In general, a simple expansive engine will become uneconomical and can be replaced to advantage by a compound, at least as far as coal consumption is concerned, when the real cut-off is earlier than that given by dividing 22 by the sum of the absolute initial pressure in pounds per square inch and 22.

If the cylinder is steam-jacketed and well protected otherwise by non-conducting material, the cut-off may take place quite a little earlier without excessive cylinder condensation, when the simple expansive engine may show as high economy as a poorly designed compound engine, and, under favorable conditions, it may show even greater economy.

A UNIQUE FIRE-ENGINE

F. O. Jones, Ex-Chief Engineer



THE difficulties that confront modern fire-fighters have led to the introduction of many curious contrivances. The latest, but by no means the least, of these is now in possession of the New York City fire department. It is a fire-engine that does not throw either water or chemicals of any kind, but which, nevertheless, marks the inauguration of a new and important branch of the fire-service.

In brief, this new engine is a complete and very compact electrical-lighting plant mounted on wheels. The idea of having such a machine at fires would have been ridiculed ten years ago, but many things that our fathers looked upon as foolishness have developed into wisdom with us.

As to general appearance, this new engine so closely resembles an ordinary fire-engine that it might easily be mistaken for one in the semidarkness. But let us proceed to a description in detail.

To begin with, suspended between the rear wheels is the upright tubular boiler used in all fire-engines for the quick generation of steam. Between this and the driver's seat, which occupies its customary place on the front end, however, the novelty comes in. The pumping machinery has disappeared, and in its place there is a small but

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powerful dynamo, which is connected to a high-speed engine. Just back of the driver's seat is a small iron platform that holds what is perhaps the most important part of the whole machine—two projectors, or search lights.

These Rushmore projectors are of the same general type as those used on board our war ships, but owing to the nature of the work they were made for, have less power. The lenses are 18 inches in diameter. For long-range work, a plain lens, throwing parallel beams of light, is used; or, by using the special deflecting glass fronts, a large area may be covered at short range. The projector tubes, or barrels, which are sheathed with copper, are 2 feet long and hung in the center on fork-like standards. By turning these standards, the projectors may be made to describe the entire horizontal circle, or, if turned on their pivots or bearings, the entire perpendicular circle. The combination of these two movements permits of their being used in any possible direction. The lamps are self-regulating, and an adjustable rheostat for each is located under the driver's seat, in order to allow the current to be adjusted.

Provision is also made for removing the projectors from the engine. When occasion arises, one or both projectors may be carried to any point of vantage, such as an alley, the rear of a building, or even into the building itself. To permit of this being done, two extra bases, holding reels wound with 200 feet of mining-machine cable, are carried on the rear framework, directly over the fuel pan. In the base of the reels are sliding connections. When a projector is removed, one of the reels takes its place on the forward platform. The extra base is carried wherever wanted and the projector mounted thereon. It may then be operated the same as when on the engine.

The normal speed of the engine is 650 revolutions per minute, and drives the direct-connected generator that furnishes a current of 65 amperes at 80 volts, and this in turn a light of 8,000 candlepower in each of the projectors. This Bullock generator is entirely enclosed, so that it is impossible for rain or stray fire-streams to damage the armature or field windings. The engine, built by W. B. Forbes & Co., has $5'' \times 5''$ cylinders, and is extremely light and compact for its power. It is also provided with a sensitive shaft governor that gives close speed regulation. Each projector is rated at 8,000 candlepower when taking a current of 35 amperes. This throws ordinary arc lights into the shade, and rays of such power and brilliancy will not only throw into bold relief the side of a building, but what is even more to be desired, they will pierce smoke almost like sunlight.

This novel fire-engine is located in one of New York's down-town engine houses, undergoing a practical test of its usefulness. It is only used, of course, at fires of some importance that occur during the night, and when wanted is called for by a special signal. The crew of four men that operates it consists of a foreman, two engineers, and a driver. It is drawn by two horses, being what firemen term a "two-horse hitch." Upon arriving at a fire, it is placed in the most advantageous position and the current turned on. With such powerful lights as these creeping everywhere, there should be small need of the insignificant lanterns or other sources of light.

One of the greatest hindrances to firemen is darkness. When this has been dispelled by the search lights, they will be able to work much more rapidly and surely, not only in subduing the fire itself, but in saving human life, which is all-important; indeed, the engine was built with the latter object chiefly in view.

This new departure in fire-fighting appliances is the idea of Chief Croker, who was for many years assistant to Chief Bonner, and lately succeeded him as the head of New York's department. It was manufactured by La France Fire-Engine Company, of Elmira, N. Y., and cost not far from $5,000. Its weight is 6,500 pounds, or about the same as that of an ordinary steamer. The accompanying figure will give a good idea as to the general appearance of the engine.

Though somewhat in the nature of an experiment, there can be no question of its value or utility. The only wonder is that the idea was not sooner conceived and put into execution. In all probability not many years will elapse before all large cities will have their search-light engines.

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CHURCH-ROOF CONSTRUCTION

Constructor

THE VAULTED ROOF USUALLY A FEATURE IN CHURCH ARCHITECTURE—TWO METHODS OF BUILDING THE TRUSSES, WITH DETAILS OF CONSTRUCTION AND FINISH

THE underlying principles of Gothic architecture are the concentration of weights on isolated piers and balanced thrusts. These great principles, however, are seldom to which medievalists applied it. Since, therefore, we cannot follow out the true principles of Gothic architecture, and as we cannot build with massive walls and strong

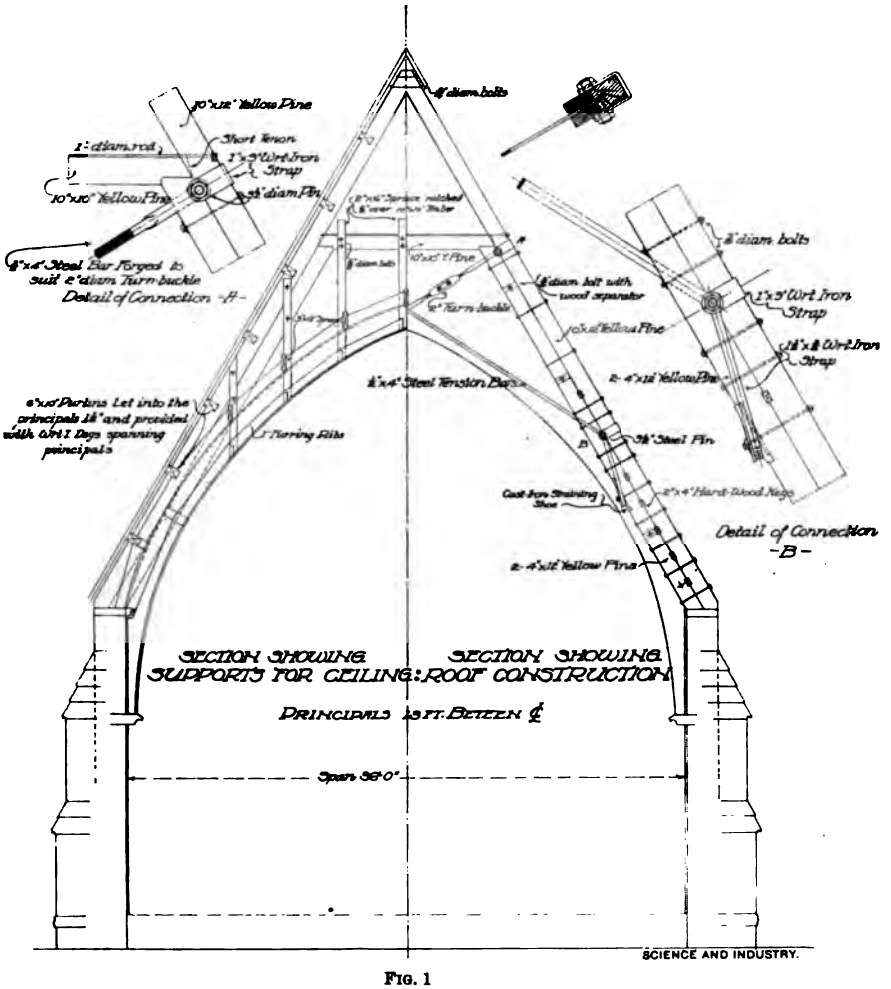
10"x12" Yellow Pine
1" diam. rod
Short Tenon
1"x3" Wrt Iron Strap
10"x10" Yellow Pine
1¼" diam. Pin
4"x4" Steel Bar Forged to suit 2" diam. Turn-buckle
Detail of Connection -A-
4" diam. bolts
10"x12" Pine
4" diam. bolt with wood separator
2" Turn-buckle
10"x12" Yellow Pine
6"x12" Purlins Let into the principals 18" and provided with 6 Wrt I Bars spanning principals
Herring Bills
8"x4" Steel Tension Bar
¾" Steel Pin
2-4"x12" Yellow Pine
Cast Iron Straining Shoe
2-4"x12" Yellow Pine
Detail of Connection -B-
SECTION SHOWING SUPPORTS FOR CEILING
SECTION SHOWING ROOF CONSTRUCTION
PRINCIPALS 18 FT. BETWEEN ℄
Span 36'0"
SCIENCE AND INDUSTRY.

FIG. 1

realized in the modern church edifice. The reason for this is evident, as the roofs are constructed of timber, not of stone, and the masonry required in the walls is too expensive an item to be indulged in to the extent buttresses, the roof must be so constructed as to be self-supporting. By self-supporting is meant that the space spanned by the roof proper is clear of intermediate supports, and that the roof is not dependent for its stability

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on shore posts, props, buttresses, or heavy walls of masonry designed to resist great horizontal thrusts.

The roofs of most modern churches and chapels are of steep slope, as, in this manner, the Gothic effect usually desired in ecclesiastical work is emphasized, though the steep roof is not a necessary adjunct to this style of architecture. From a constructive point of view, the steep roof is an advantage in one way, and a disadvantage in another; for, as the slope of the roof increases, that is, becomes steeper, any horizontal thrust, due to the vertical load, is decreased, but the oblique reaction at the foot of the principals, due to the wind pressure, is increased. By proper provision in the construction of the trusses, the tendency of the rafter members to spread and create horizontal thrusts under vertical loads can be eliminated, and all the forces on the walls will be vertical. The same tendency of the rafter members toward movement at their feet is created by the wind pressure, unless the roof is of an exceedingly steep slope, or the windward end is on rollers. This movement of the rafters is likewise taken care of in the construction of the truss.

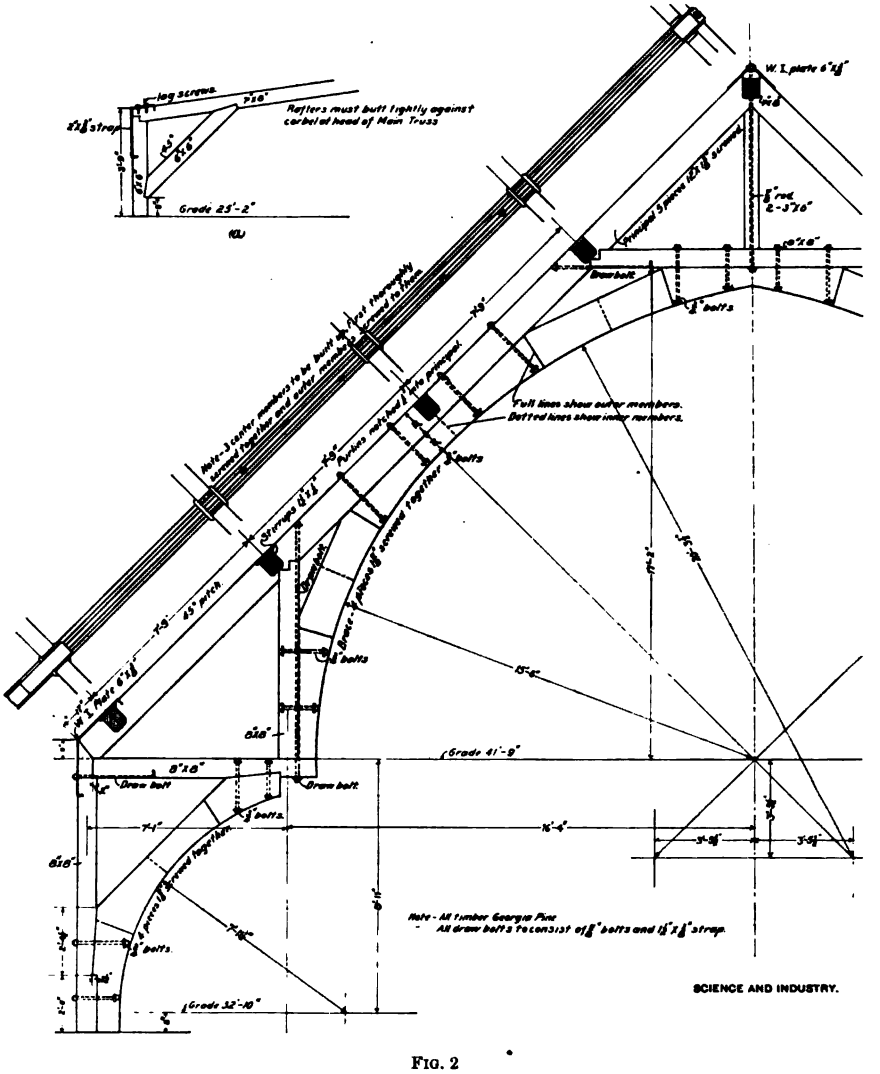
Rafters must butt tightly against corbel of head of Main Truss
Grade 25'-2"
W. I. plate 6"x8"
Principal 5 pieces 10"x8" screwed
Draw bolt
Full lines show outer members. Dotted lines show inner members.
Struts 8"x8"
Grade 41'-9"
Grade 32'-10"
Note - All timber Georgia Pine
All draw bolts to consist of 8" bolts and 12"x8" strap.
SCIENCE AND INDUSTRY.

FIG. 2

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Since the principals of the ordinary church roof are frequently secured to the wall plates, and as the wind pressure is normal to the slope, and, consequently, acts in an oblique direction, the reaction at the feet of the trusses, caused by the wind, is likewise oblique, and for this reason, even when the truss is self-supporting, the walls must have considerable resistance against lateral movement. The weight of the roof, however, materially assists them to maintain their equilibrium, and the usual thickness of walls demanded by good practice in masonry is all that is required, especially as the walls in these structures are often reenforced by buttresses designed mainly for appearance and to give the building the earmarks of a Gothic edifice.

Fig. 1 shows the construction of a steep roof and vaulted ceiling over a small chapel. The difficulty in this case was that tie-rods could not be carried down to the heel, or foot, of the rafter member, because in so doing they would protrude through the finished line of the ceiling. The effect desired in the interior was that of a plastered ceiling, with plastered ribs occurring directly beneath each principal, the ceiling springing from a molded cornice, and the ribs from a corbel projecting from the wall somewhat

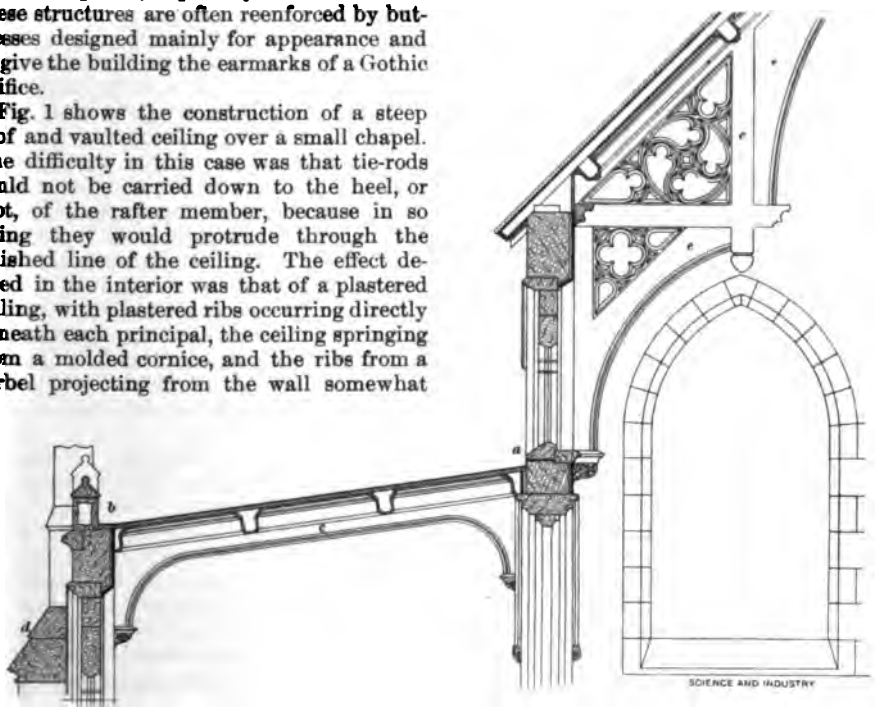

FIG. 3

lower down. It was desirable in this case that the truss be self-supporting, consequently the members had to be retained against spreading. This was done by introducing the tension bars with turnbuckles, as shown. In order to realize the full strength of these bars, it was necessary that they should be fastened with some security to the timber member. The efficient manner in which this was done can be seen from a detail of the connection at *B*, and, from this detail, it will be noticed that as the stress increases on the bars, the tighter the grip of the connection will become. Since these tie-members do not run to the foot of the principals, there is created at the point *B* considerable bending moment that must be resisted by the transverse strength of the timber forming the rafter member. It was found necessary, in order to obtain sufficient strength and provide means of making a secure connection, to form of this member a compound beam. This was accomplished by using an outside piece of $10'' \times 12''$ yellow pine, and bolting to it two pieces of $4'' \times 12''$ yellow pine, leaving a 2-inch space between, through which it was convenient to extend the tension bar and secure it to the pin. Though the timbers are firmly held together by bolts, they are not secure against the tendency to slide along their junction created by the transverse stress, and, in order to eliminate this tendency, hardwood keys were inserted, as shown. The straining beam on which the tension bars pull, as it were, must also be of stout timber, which is held in place by a short tenon and bolt, binding the truss together at this point. Of course, the $10'' \times 12''$ timber need not have been extended to the apex, as a light framework could have been built above the straining beam. This

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would not be good practice, however, because the line of demarcation between the light and heavy construction would surely show on the roof from the exterior, on account of settlement or deflection, which in time is certain to occur in almost every timber structure.

The 6″ × 10″ purlins are notched into the principals 1½ inches, and are provided with wrought-iron dogs spanning the principals and driven into the adjacent ends of the purlins. This holds the structure firmly together, longitudinally, though there is little tendency for movement in this direction, where gables are erected at each end. Furring ribs must be provided for the ceiling, which are supported as shown, being notched and toe-nailed between 3″ × 12″ spruce joists hung from the truss by 2″ × 6″ pieces. These timbers in some positions are notched over the truss and bolted, and in other places simply bolted to the principal. The ribs should be as narrow as possible, in order to avoid excessive shrinkage, and thus reduce any tendency for the ceiling to assume warped surfaces, which are sure to show up disagreeably as the light is reflected on the plaster.

Interior treatment of the church or chapel often demands that the timber trusses shall show and form a part of the decorative features, and that the construction of the entire roof shall be plainly visible. This principle is truly architectural, because high art in architecture is the ornamentation of construction, not the construction of ornamentation. When this treatment is required, it is necessary that the truss shall be so constructed as to offer a pleasing appearance. Diagonal tie-rods of iron or steel are rather unsightly, and, consequently, they cannot be used unless, of course, they are hidden in the timber work.

The truss that meets the requirements best is that known as the *hammer-beam truss*. In this truss, the usual form of which is shown in Fig. 2, there is considerable bending moment created at the middle of the principal rafter, which, unless resisted by the transverse strength of the material at this point, creates a horizontal thrust that must be taken up by the roof of the side aisle. If there are no side roofs, the main walls have to be properly strengthened by buttresses. The purlins in this design are separated by wrought-iron stirrups as well as being notched ½ inch into the principal. This is excellent construction, since the timber is weakened very little.

From Fig. 3, it will be seen how susceptible is this construction to architectural treatment. It will be noticed from the sketch that the lower end of the hammer beam resting on the gable, and running the full width of the clearstory of the nave, is carried on an arcade running lengthwise of the building. This arcade offers little resistance to deflect sideways, and, consequently, as there are oblique reactions due to the wind and a possibility of some horizontal thrust due to the truss changing form under its loads, they should be stiffened in some manner. This purpose is accomplished by the rafters of the aisle roof, as previously mentioned, the construction of which is shown at (*a*), Fig. 2. These rafters act as shore posts; any tendency for the arcade to move sideways is transferred back to the abutments, which are built on the outer wall.

There is little else that can be said in regard to these trusses. The drawings are working drawings, and clearly show the construction in all its details. While there are many ways in which problems in construction can be met, these two examples may offer some suggestions that can be followed in many cases. They have proved practical, because they have been actually built and occupy today their positions of trust, by maintaining the integrity of the roofs over several edifices, and, though the details of construction may be modified somewhat to meet special requirements, they offer good examples in timber construction as applied to church roofs.

SOLUTION FOR ACETYLENE GENERATORS

ACETYLENE generators may be prevented from freezing by making a saturated solution of common salt and water and charging the machine with it. Professor Lewis, one of the best known authorities on acetylene, recommends the use of this preparation in places where the machine is likely to be subject to frost. If properly prepared, the solution will not freeze until its temperature is about 6° F.

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TELEGRAPHIC CIPHER CODES

H. S. W.

USE OF TELEGRAPH CODES—CIPHER OR SECRET CODE—HOW A CIPHER CODE IS MADE

DURING our war with Spain, and in the war in South Africa, most all cable messages, in order to decrease the cost of transmission, were sent by some sort of code, and important government messages were sent in a cipher code. Very few persons realize how extensively telegraph codes are used, and how easily a cipher code can be arranged by the help of some code book, of which there are several on the market.

The only signals that can be sent over a cable or telegraph line are the dot and the dash. All letters of the alphabet and all numerals are made by combinations of these dots and dashes, with intervening spaces. Then the letters and numerals may be combined and transmitted in any order that suits the sender of a cable or telegraph message. There are several very extensive and complete code systems arranged for the general public, but they are used mostly for sending cablegrams. By their use, a long message can be transmitted by means of a few words, and thus the cost, which might otherwise be very high, can be made quite reasonable. These codes, which are published in book form, make quite a fair-sized book, of which both receiver and sender must have a copy, as the telegraph and cable companies do not form or translate messages. By the use of a code, a secret or private cipher can very easily be arranged, as will be shown presently.

The method of using a code can be illustrated best by an example, using some particular code. Each page in the A-B-C code book is divided into three columns. In the first column are figures from 1 to 99,999, inclusive; in the second column are words or combinations of letters arranged alphabetically; and in the third column are placed the words, phrases, or sentences that the numbers or words in the first or second column represent. Suppose that the body of a message to be cabled is as follows, the address and signature being omitted:

Tugs now assisting; we write you full particulars.

In the code book, the sender of the message would look up the important words "tugs" and "write." These two words would be found in their proper places, and the complete line containing each is as follows:

14,643	*Turtle*	*Tug (s) now assisting.*
15,419	*Worthily*	*I (we) write you full particulars.*

The body of the message would then be written by the customer ready for transmission as follows:

Turtle Worthily.

The sending operator would transmit these two words, and the party to whom the cablegram was addressed would find the meaning by looking up in his code book the two words, "turtle" and "worthily." Thus, instead of eight words, only two need be transmitted and paid for. In this way, all cablegrams can be shortened and sent at much less expense by the use of a code.

By the use of such a code, any one can arrange a secret or private cipher. To do this, take some word in which no letter is used more than once, and, preferably, a word that has ten letters. The word "cumberland" satisfies these two conditions. Arrange it as follows:

c	*u*	*m*	*b*	*e*	*r*	*l*	*a*	*n*	*d*
1	2	3	4	5	6	7	8	9	0

In the first column of the code book, opposite the two phrases "Tug (s) now assisting," and "I (we) write you full particulars," are the two numbers 14,643 and 15,419, respectively. In the word "cumberland," *c* represents the numeral 1, *u* the numeral 2, and so on. Thus, the number 14,643 is represented by the group of letters *cbrbm*, and the number 15,419 by *cebcn*. On the message blank, the sender using this cipher code would write, as the body of the message, the two following combinations of letters, for they are not necessarily words:

cbrbm cebcn

These letters would be transmitted in groups exactly as written, and the party to whom the message was addressed would first translate it into the two numbers 14,643 and 15,419 by means of the private code word "cumberland" and the numerals corresponding to each letter in this word.

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Then, by looking up these numbers in the code book, the correct meaning would be obtained. It is evident that only the parties knowing what numeral corresponded to each letter in the code word could interpret the message. Thus, it is quite easy, even by using a code book, which can be purchased anywhere, to arrange a cipher or secret code. The ten letters may even be chosen at random from the alphabet; it is not necessary that they form a word.

If a code is used having, say, five numerals in it, that is, if it runs up to 99,999, then each combination of letters transmitted should contain just five letters, neither more nor less. Therefore, if the number is less than 10,000, ciphers must be prefixed to make five numerals, and the letter corresponding to the cipher must be written on the message blank and transmitted. This makes each combination of letters transmitted contain the same number of letters; in the case of the A-B-C code, used as an illustration, there will always be five letters in each combination. This is necessary to avoid the risk of a wrong grouping of the letters by either the sending or receiving operator. Suppose, for instance, that the word "best" were to be sent. In the code book would be found:

1,734	*Becalming*	*Best*

There are only four figures in 1,734, but five must be used by prefixing a cipher; thus, 01,734, and the corresponding combination of letters to be sent would be *dclmb*.

If the various governments possessed not only a secret code word, but also their own secret code book, it would be utterly impossible for any one, not possessing both the government code word and book, to translate the cipher messages.

HOW TO PREPARE YOUR HEATER FOR THE SUMMER

Harold Björnsen

HEATERS DEPRECIATE VERY MUCH DURING SUMMER WHILE STANDING IDLE — HOW TO AVOID TROUBLE AND EXPENSE IN THE FALL

NOW that the heater in your cellar has kept your house warm and comfortable for the last six or seven months, and you are about to throw it out of commission, a few hints on how to "fix" it for the summer will not be out of place.

Of course, we know you are terribly disgusted with your heater now that the winter is past — everybody is that has had the never-to-be-forgotten experience of running a house heater when the mercury stands at one of those weird marks below zero and the wind is a piping gale. Perhaps, in your haste to get to business, you have even forgotten to put on coal some morning during the trying season, and on returning have found your poor wife hugging the hot-water boiler in the kitchen to keep warm. It is natural for a householder to grumble a little about his heater, particularly when he has neglected to instruct his wife how to attend to it during emergency cases, and it is only to be expected that, when spring comes and he feels free again, he will drop it like a hot potato, and let it stand untouched and unattended until the next fall.

Let me narrate the experience of a dear friend of mine, an impecunious man of vast intelligence, who in his study is a giant among men, but in his cellar is like a fish out of water. He put upon himself the responsibility of keeping the house warm during winter with a steam boiler he had in the cellar. He knew the theory of steam generation, and could compute to a decimal point the B. T. U.'s that should be given off by any amount of steam. He could deliver an excellent lecture on combustion, from a common candle up to a whole winter's supply of coal. But the running of his little steam heater almost demoralized him. However, like all other brave men, he stuck tenaciously to his self-assumed task, and, somehow or other, managed to wiggle through the winter. In the spring of last year this martyr hailed me with a smile that brightened his whole face and predicted good news.

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"Björnsen, old boy," he said, "it's all over now—for a season at least. Don't you think Thanksgiving Day ought to come in May as well as in November?"

"Why? What for?" queried I, not seeing things as he at that moment saw them.

"Because," he continued, "I shut down on the heterogeneous mass of old steel and iron in my cellar that has been gormandizing good coal and vomiting abominable ashes all winter."

It is needless to say that I appreciated his admirable reasons for Thanksgiving in May.

"But," I remarked, "did you fix your heater for the summer, and is everything in good shape for next winter?"

"Fix nothing," he replied, disgustedly; "I will attend to that next fall. I am only too glad to be able to leave the old thing alone for a few months. Wouldn't you do the same?"

"No, sir; not any more. I got my lesson about four years ago, and I clean out my heater every spring now, and fix it for the summer before it is actually cold. While giving it a thorough cleaning out, I examine all the different parts, and if any repairs are required I get them done during the summer; then everything is ready for service at any moment."

This apparently did not meet with the approval of my friend, for he neglected the heater all summer, trusting in Providence and the maker's name on the boiler front that everything would be all right in the fall. But Providence only helps those that try to help themselves, and boilermakers' guarantees do not cover neglected boilers; so he met his Waterloo last winter. A cold snap came along without warning, and reminded him of his boiler duties. He rushed down to the cellar, spoiling a good three-dollar derby that protected his head from collision with a steam main. He tried to open the fire-door, but it was rusted fast and would not yield. Then he tried the ash-pit door, but that was just as bad. "Humph," he ejaculated, while the perspiration began to show on his noble brow, "this is a good omen—a bad beginning usually makes a good ending." So he heroically hurried to the wood pile for the ax, murmuring something about "this heater reminds me of the month of March; it begins service like a lion; I suppose it will finish up like a lamb." With such beautiful and inspiring thoughts flitting through his mind, he nobly tried to pound the fire-door open. Of course, he hit the wrong place, and the door fell on the floor—breaking off at the hinges. This made him send for a steam fitter, who promised to come "right away."

But there were more men in town like my friend, and they all wanted steam fitters at the same time, so the much-desired individual did not appear as quickly as promised or even as expected. The weather got colder toward evening, and the house became unbearable. The wife and little ones had to go "visiting" to keep warm, while my poor friend returned to the cellar and resumed operations with the ax. This time he tried the ash-pit door, and after repeated shocks it at last flew open, and he was happy again.

"Now," he chuckled, "I will get a fire in it anyhow, and we'll have steam up before they return from their visit."

The ash-pit was full of cold, damp, clammy ashes, and so was the fire-pot. He shoveled the ashes out of the pit, then lifted more out of the fire-pot with his hands, for they were too damp to fall down through the grate. Then he examined the dirty water gauge, and he was sure the water was just where he left it last spring, and his last precaution was to lift the safety valve off its seat to see that it had not stuck fast like the doors. Finally, with his soul full of hope and his teeth chattering in his head, he prepared a fire in the heater. Being in a hurry, he literally filled the firebox and combustion chamber with paper and wood, and started a fire that was destined to give him more trouble than the rusted doors—a fire that almost brought the local fire-brigade on the scene. The flames leaped up rapidly through the paper and wood; smoke belched forth into the cellar through the open fire-door. He hurried to put on the broken door and thus keep in the smoke, but before he could place it the smoke burst into flame and singed his whiskers. For a moment he fell back astounded at the ferocity of the flames, whose darting tongues now licked the ceiling joists and threatened the destruction of his home. To put on the broken door was out of the question, but presence of mind saved the house, for he instantly closed the ash-pit door with a ferocious kick that stubbed his toe and made him wince. This shut off the larger portion of the air supply to the fire, and of course subdued it somewhat, causing more smoke and less flame to shoot into the cellar. Then he fitted on the broken door and propped it up with the coal shovel. This done, our invincible friend opened the ash-pit door again to "whoop her up," as he expressed himself later on, but she would

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not "whoop." Smoke poured into the cellar through every crack and crevice of the heater, until it looked like Moses' burning bush, which smoked but was not consumed.

He was sufficiently acquainted with boilers to know that the cause of all this smoky turbulence was nothing but defective draft, and this he attributed to a cold chimney. The chimney certainly was cold, but it apparently would not get warmer, for at the end of a most trying hour the draft had not improved and there was not an ounce of steam pressure in the boiler. As the family returned, the idea just dawned upon him that the flues might be choked somewhere. Then he fearlessly commenced to take down the smoke pipe, which crushed under the pressure of his hands. When matters became so plain that he must put in a new smoke pipe, he simply tore it all apart, cleaned out the base of the chimney, which was choked enough to prevent a good draft, and after extinguishing the fire entirely, he cleaned out the boiler flues.

But there is no use of further detailing the poor fellow's troubles; suffice it to say that the steam fitter came the next day, discovered that the boiler was defective, took note of some "repairs" that had to be ordered from the manufacturer, whose works were more than 150 miles distant, then went away, not to return until ten days later, when he made the boiler as good as new. In the meantime the boiler could not be used; some vital part had to be renewed before steam could be raised. During these ten days of terrible suspense, a keen, bitter wind froze some of the plumbing, and created a new source of trouble and expense.

Reader, profit by other people's experiences. As a rule there is some damage done by a season of hard running that should have attention as soon as the heater is shut down. But apart from the risk of being caught by a breakdown, there is the fact that a heater depreciates very much when allowed to stand all summer choked with ashes and soot.

The following suggestions may help you to save dollars, and avoid doctors' and plumbers' bills; they are particularly applicable to the preparation of a steam heater for the summer.

Boil the water furiously for a few minutes with a brisk wood fire, to agitate the sediment that may be in pockets of the heater. Then, with a 5- or 10-pound steam pressure indicated on the gauge, open the blow-off cock and allow the boiler to empty itself quickly. Draw the fire while the boiler is blowing off.

As the heater cools off, remove the ashes, both from the fire-pot and ash-pit. Brush or scrape these chambers clean. Clean out all the boiler flues thoroughly, removing all soot, dust, and as much scale as possible. Remove the smoke pipe and scrape or brush its inner surface perfectly clean, then store it in the attic or some other dry place. Clean out the chimney flue and leave the hole open to act as a ventilator to the cellar during summer. Swab out the gauge glass, if there is any way by which you can get a small sponge inside the glass tube. Fill the boiler up to the safety valve with hot water drawn from the kitchen boiler. This water, if it has been boiled, is preferable to cold water, because it is practically free from air and other gases that tend to corrode the inside of the heater. Remove the weight from the lever of the damper regulator, so that the rubber diaphragm inside will not be torn or otherwise injured by the strain during summer. Scrape, or rub clean, with sandpaper, the faces of all doors and dampers that are supposed to close tight, then rub these surfaces with mutton tallow, glycerine, or any other matter that will protect them from corrosion during summer. Leave every part of the heater thoroughly clean. Varnish with "Japan black" all surfaces that are liable to become corroded by dampness in the cellar. Leave everything "spick and span," and you will have no trouble in the fall when you start your heater up for the next winter.

Ventilate your cellar or boiler room well during summer. If you have anything stored there that you want to keep cool, it would be well to partition off part of the cellar to contain it. It will pay you to keep your cellar or boiler room well ventilated.

If you have neglected to fix up your heater for the summer, kindly accept this article as a friendly reminder, and order all repairing done before fall.

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LEAD-COVERED ELECTRIC CABLES

THE electric cables shown in the accompanying figures are of interest, as they illustrate the present practice along this line, and are representative of the different classes commonly used. The figures

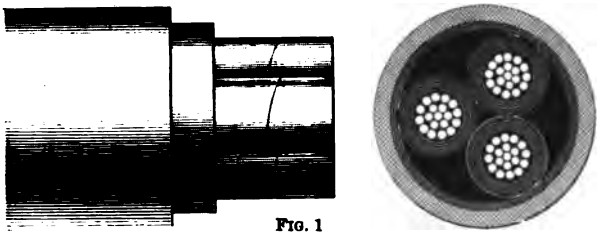

FIG. 1

show the cross-section of these cables two-thirds actual size and give a good idea of the thickness of insulation, lead covering, etc.

In Fig. 1 is shown a cable made up of three stranded conductors, each equivalent to a No. 0 B. & S. wire, each conductor being made up of 19 strands. This cable is intended for high-tension light and power distribution work in connection with the three-phase system, and, hence, the insulation must be quite heavy. The insulation around the conductors is $\frac{1}{8}$ inch thick, and is made up of several layers of paper treated with insulating compound. The space between the 3 strands is filled with fibrous insulating material, and treated with insulating compound. Over this a wrapping of paper about $\frac{1}{16}$ inch thick is applied, and on

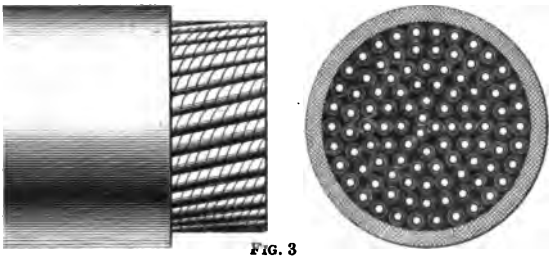

FIG. 3

the outside is the lead covering, which is $\frac{1}{8}$ inch thick. The whole insulating material is very hard and dense, and offers a high resistance to puncture. Such a cable is used when it is desired to transmit high-tension currents underground, as is often done in connection with city light and power plants.

Fig. 2 shows a cable also designed for underground power-transmission work, and represents a type of cable used largely for underground feeders for street-railway systems. Since the power used for this work is usually transmitted at a fairly low pressure of about 500 volts, the current becomes very large where many cars are operated, and for this reason these cables need a very large cross-section of copper. The one shown in Fig. 2 is made up of 91 wires and has a total cross-section of 1,375,000 circular mils, or more than 1 square inch of copper. Cables of this kind are, of course, used altogether for underground work—railway feeders for overhead work

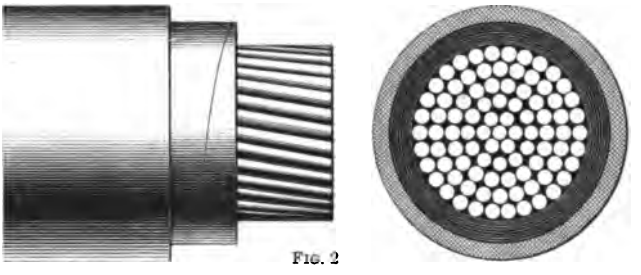

FIG. 2

are provided simply with a braided covering instead of the lead sheath. This cable is also insulated with paper treated with insulating compound, the paper insulation being about $\frac{1}{16}$ inch thick. The lead sheath is $\frac{1}{8}$ inch thick, and the diameter of the cable over all is very nearly 2 inches.

Fig. 3 shows a cable designed for telegraph work. Each conductor is provided with a paper insulation. The paper is treated with insulating compound, as in the previous cases, and the whole bundle of conductors stranded together as shown. This cable contains 100 conductors No. 14 B. & S. The lead sheath is $\frac{1}{8}$ inch thick, and the outside diameter of the cable is $1\frac{5}{16}$ inches.

A cable designed for telephone work is shown in Fig. 4. Its construction differs greatly from those shown in the preceding

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figures. The requirements of telephone work call for a cable that will have as small an amount of capacity as possible. In order to overcome the effects of induction, the wires are grouped in pairs and twisted together; this, in fact, constitutes a complete system of transposition, and is only carrying out to a greater degree the practice of crossing the wires at intervals on the poles, as is done in pole-line work. In order to keep down the electrostatic capacity, the wires are insulated with a loose wrapping of paper, which allows more or less air space around them. The paper used is not treated with insulating compound, thus constituting what is known as a *dry-core* cable. In making up the cable, the different strands are not twisted as firmly together as in ordinary cables, and the result is that the wires are separated by an air space that has a considerably lower specific inductive capacity than the insulating materials ordinarily used. It is very essential that moisture should be kept out of a cable of this kind, because, should it get in, the working qualities of the cable would be very much impaired, and the cable might even become entirely disabled. The cable shown in Fig. 4 contains 102 pairs of wires, or 204 conductors. The lead sheath is about $1\frac{1}{8}$ inches outside diameter, and is $\frac{1}{8}$ inch thick. Two different colors of paper wrapping are used in order to mark more distinctly the wires belonging to each pair. The above drawings were made from samples of cables kindly furnished by the National Conduit and Cable Co., of Hastings-on-Hudson, N. Y.

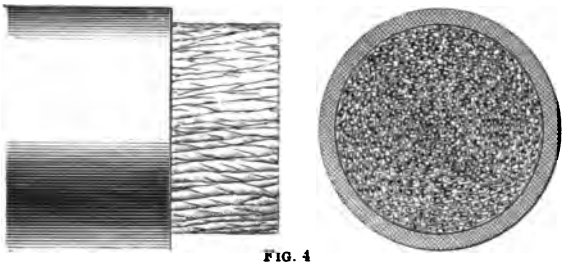

FIG. 4

ENERGY REQUIRED FOR A TELEPHONE RECEIVER

H. S. W.

THE small amount of energy expended in a telephone receiver is remarkable. An ordinary well-made receiver requires only $\frac{3}{100,000,000,000}$ watt to make it give an audible sound. Since 746 watts is equal to 1 horsepower, then $\frac{3}{100,000,000,000}$ watt $= \frac{3}{74,600,000,000,000}$ horsepower. Now, 1 horsepower is equal to 33,000 foot-pounds per minute; that is, if a person lifts 33,000 pounds a distance of 1 foot in 1 minute, his rate of doing work is 1 horsepower. A little calculation will show that the work done in lifting 1 pound a distance of 1 foot, that is, a foot-pound of work, would be sufficient to supply a receiver with $\frac{3}{74,600,000,000,000}$ horsepower for $\frac{74,600,000,000,000}{3 \times 33,000}$ minutes, or 523,250 days, or 1,433 years.

An idea of the very small amount of electric current necessary to operate a telephone receiver may be had from a measurement that showed that $\frac{44}{1,000,000,000}$ ampere would produce a distinctly audible sound in the receiver. Now, an ordinary incandescent 16-candlepower lamp requires about $\frac{1}{2}$ an ampere (at 110 volts). So that 11,360,000 telephone receivers could be supplied by the current required by one of the above lamps if this current were divided up equally among them.

Of course, there is considerable loss in efficiency between the source of the electric current and the receiver. The above figures take no account of this, only the energy expended in and the current passing through the receiver itself having been considered. A properly constructed and adjusted telephone receiver is not only very efficient, but it is one of the most sensitive instruments known to science.

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INTERIOR PHOTOGRAPHY

Louis Allen Osborne

THE KIND OF CAMERA AND LENS MOST SUITABLE—THE POINT OF VIEW—HALATION, HOW TO AVOID IT, AND REMEDY IF UNAVOIDABLE

PHOTOGRAPHY as a means of recording facts is becoming of more importance every day, and there is hardly a lawsuit involving patent infringement, railroad or mine accident, or damages for effects produced by operation of certain manufactories that the photograph is not called as a most important witness. As a means of illustrating a process of manufacture or a system of working, no amount of written matter can convey as much information as a single well-taken photograph, and the most carefully prepared drawing will never convey to the observer that feeling of fidelity to truth and facts as does the mechanical record of the scene portrayed by the camera. Plans, elevations, and other working drawings may be essential preparations for the erection of a mill or factory, but a prospective purchaser of the building wants to see a photograph of the structure before he closes the transaction or travels any great distance in the interest of the investment.

Photography, therefore, is most useful to man in its commercial branch, and the camera as a rapid means of recording facts occupies a position in the business world today almost as important as the typewriter.

Interior photography is undoubtedly one of the most difficult problems that either the amateur or professional operator is called upon to solve. This may account for the fact that there is little of practical value to be found on the subject in photographic manuals that treat extensively on other branches of the art. Few operators continue long at this branch of the profession, if they can get a different class of work, and the few that master some of its intricacies are not inclined to impart to the public the details that have cost them so much to acquire.

It is therefore the purpose of this article to suggest to the inexperienced a few of the tricks and devices that may be resorted to, so as to remove or lessen some of the difficulties that beset this class of work.

It is assumed that the reader possesses a certain amount of photographic experience and has a general idea of the conditions necessary to secure satisfactory results in outdoor photography—conditions that never exist with interior work, although a knowledge of them is indispensable in its practice.

The photographing of a room in a dwelling house is probably the simplest form of interior photography, though even this brings us against obstacles before unknown; but the photographing of an engine room, or of a machine shop, breaker, or cyanide mill confronts the operator with difficulties of a most discouraging character. In the dwelling house he can move or rearrange the furniture so that no detail will be so near the camera as to appear in exaggerated proportions, and he can close up the room and give an exposure of half an hour if the circumstances require it; but in a manufacturing establishment he must deal with the unalterable facts and conditions just as he finds them.

Not only has he to contend with the difficulties of improper lighting and exaggerated perspective, but also with such annoyances as dust, vibration of machinery, reflection of light from moving parts, and interrupted exposures due to carelessness on the part of some employe who deliberately gets in range of the camera just as the shutter is opened.

The prevention or cure of all these difficulties is not successful in every case, but the extent to which they can be eliminated depends almost entirely on the skill and care of the operator, both before and after the exposure. In fact, there are many cases where the exposure *must* be made under the most adverse circumstances, and the entire subject manipulated during or after the development.

The style of camera used for this class of work is of little importance, though a light, compact, folding camera, of the tourist pattern is not as adaptable as a heavy and somewhat more cumbersome one. The essential requirement is that it shall be steady and not easily upset or jarred out of position, even though it is somewhat clumsy to carry around conveniently. It will get more or less rough usage, and it is far better that it should be strong enough to stand the strain than that it should be light enough to be carried with ease.

The lens should be of as long focus as

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possible. There are many photographers who will differ with this statement, but the longer the focus the less the distortion, and the sharper the definition of details at

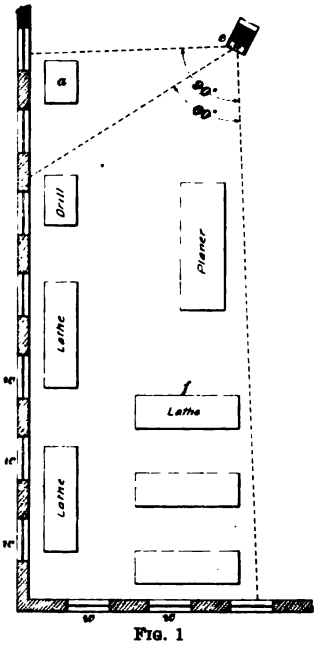

FIG. 1

varying distances from the camera. There are frequently circumstances, however, where a short-focus lens must be used to get certain details on the plate, and other circumstances where two exposures can be made to include two sides of a room, and then the prints mounted together as one picture. A lens, the focal length of which is not less than the diagonal measurement of the plate, is the best for all around work, though one of half this focus may occasionally be required. Thus, for a $5'' \times 7''$ plate the lens should be about $8\frac{1}{2}$ inches focus, so that the angle included between lines drawn from diagonally opposite corners of the plate to the center of the lens will be about 60°. Where the lens is only half this focal length the included angle is about 90° and the lens is called *wide-angled*.

To determine (approximately) the focal length of your lens, focus it carefully on a very distant object and measure the distance from the diaphragm of the lens—if it is a double combination—to the ground glass of the camera, or from the lens itself to the ground glass, if it is a single combination. This distance will be very nearly the focal length of the lens.

The camera should rest on a strong, heavy tripod, as the instrument is in constant danger of rough treatment, especially in factories where the employes are moving around considerably. The tripod of a surveyor's compass or transit is well suited to photographic work where there is much vibration or jar from the machinery.

The plates to be used should be slow ones, as snap-shot photography seldom enters into this class of work, and a slow plate is always much more reliable under conditions involving some uncertainty than is a fast one. Non-halation plates can always be used to advantage, and especially under certain circumstances pointed out hereafter.

The selection of the point of view will in most cases be determined by the location of machines or other fixtures in the building, as will be indicated in a few examples hereafter given.

The exposure of the plate will be governed usually by the darkest portions of the interior. A good way to estimate the proper exposure is to pin up, for a given length of time, in the darkest part of the room, a yellow envelope out of which one end of a piece of printing-out paper is allowed to protrude. After thus exposing it for, say, 10 minutes, put the paper all in the envelope and take it outdoors, and in the shade of a tree expose the other end until it has reached the same tint (which can be determined by pushing the paper inside and examining it by the yellow light that comes through the envelope). The ratio of time required by these two exposures will be the ratio of exposure required for your interior and an open landscape at the same time of day. For instance, if the paper darkens in 5 seconds outside as much as it did in 10 minutes inside, then your interior requires 120 times the exposure of an open landscape, and you make your calculations accordingly.

Having thus discussed the materials and preliminaries, let us now come down to the practical work. Few amateur photographers possess all the lenses, plates, and accessories necessary to practice in all branches of photography, and we will, in discussing the subject, here consider the operator equipped with an ordinary outfit, but point out the variations desirable or advantageous in each particular case.

Case I.—A long narrow shop, lighted by windows on one side, machinery arranged so as to interfere with placing of camera. (Fig. 1.)

The difficulty in this case lies principally

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with the halation that will exist from the windows *w* directly in front of the camera, which is placed at *e* so as to include within the angle of its lens the ends of the lathes *f* and the row of machines in front of the windows *w*. Nothing would be gained in this case through the use of a wide-angled lens, as its field would only include one more machine *a*, and that so near the camera that the distortion would be extreme.

Halation is caused by the reflection of light from the back of the plate. When the camera is pointed toward a window, electric light, or other source of strong illumination, the light passes entirely through the film on the plate and is reflected back to the under side of the sensitive coating, thereby doubling the exposure of that particular spot. When the plate is developed, a "halo," or over-exposed circular outline, appears around each window and destroys all the detail in its vicinity. (See Fig. 3.) Halation can, in most cases, be prevented by the use of non-halation plates. These are prepared with two coatings of the sensitive emulsion, a fast one on top of a slow one. The double coating renders the plate more opaque, and any light that may be reflected from the back of the plate falls upon the slow emulsion, which is not as sensitive.

Another method of preparing non-halation plates is to coat the backs of them with a mixture of any red or brown pigment in collodion. (Spanish rouge answers the purpose admirably.) The light reflected from the surface thus coated is red in color, and therefore less actinic.

Another good backing for plates may be made as follows: Dissolve 1 pound of sugar by heating it gradually in an agate-ware pan, and continue the heat until it turns black and shows signs of boiling. Then set it aside to cool, after which pour on a pint of cold water and allow it to soften up for two or three days. A quarter of a pound of burnt sienna should now be stirred in and the whole poured into a jar for use.

To back a plate, lay it face down in an ordinary printing frame, and rub the back of it with a rag that has been previously moistened and rubbed over the backing compound above described. Before developing, the backing should be removed with a sponge or wet rag.

The reversing of a plate will reduce the tendency to halation considerably, as the light passes through the glass plate before it reaches the sensitive coating, so that any reflection from the back is comparatively harmless. This, however, causes a reversed picture, and is not of much use except for work where the relative positions of details with regard to the right and left of the picture is of little importance.

If celluloid films are used instead of plates, the halation is reduced to a minimum, as the celluloid backing is so thin that little dispersion of the reflected light is possible.

There are times, however, when halation makes its appearance in spite of all efforts to avoid it, and other times when it appears most unexpectedly. Under these circumstances it must be taken care of during or after development. If its appearance is anticipated, a bottle of saturated solution of potassium bromide and a small sable brush should be in a handy position for use during development. Place the plate in the tray and pour on the developer. As soon as the halo makes its appearance, remove the plate and wash it thoroughly in running water. Dry the surface as much as possible with a piece of absorbent cotton, and then carefully paint the halo with the potassium-bromide solution. Care must be exercised not to get the bromide of potassium on any part of the plate that is not intended, as it will retard, if not prevent, further development. The plate should therefore be held perfectly level during its application, or it is liable to run across to the edge and ruin the

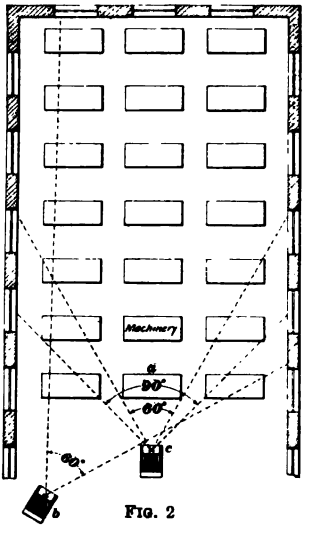

FIG. 2

negative. After the bromide has soaked into the film, the plate may be returned to the developing tray and the development proceeded with from where it was stopped.

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FIG. 3.—PRINT FROM NEGATIVE BEFORE TREATMENT

by the transparency of the negative on looking through at the white paper. When reduction has proceeded far enough, wash the negative thoroughly and place in the rack to dry.

If the halation is not too great, the negative can be reduced mechanically after it is dry by rubbing the denser parts with a soft cloth or rag dipped in alcohol. The rubbing should be slow and vigorous, and a clean spot on the rag should be taken for each new application of alcohol. Reduction by this method is slow, but very easily controlled and varied in degree.

Extreme cases of halation may be reduced by rubbing the dry negative with the forefinger dipped in powdered pumice stone, and finishing with alcohol and a rag as above. This is likely to produce scratches, however, and should be resorted to only in exceptional cases. The resulting scratches will usually disappear if the negative is varnished after the operation.

If the halation is unexpected and therefore no bromide is ready for action, it is usually better to continue the development and trust to the removal of the defect when the plate has been *fixed*, or even after it is dry. A solution of ferricyanide of potassium 40 grains and hyposulphite of soda 40 grains in 1 ounce of water, applied to the denser portions of the wet negative with a soft brush, will reduce the halo very rapidly—so rapidly, in fact, that there is danger of carrying the operation too far. In using this solution, the negative, as in the application of bromide, should be held in a level position in the left hand over a piece of white paper spread about 18 inches below; the reducer is then applied with the brush held in the right hand, and the density can be judged

The danger of exaggerated perspective in this case is reduced to a minimum by the use of a lens of moderate angle, thus excluding from the plate such pieces of machinery as are too near the camera, as at *a*.

Case II.—In Fig. 2 we have all the conditions of Case I, with the addition of the distortion caused by the lathe *a* being so near the camera. In this case it would be better to place the camera at *b*, in order to bring the conditions around more like Case I; but if the circumstances demand a view from the point *c*, then the lathe *a* must be temporarily removed or the camera raised on a box or platform, so as to look over the top of it entirely. Under the latter circumstances, the use of a wide-angled lens will give a better idea of the extent of the interior,

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as the machines in the foreground will be below the angle of vision.

The development in this case will probably require the same considerations as in Case I, with the addition of some special treatment for the detail in the foreground. If the exposure is made to suit the foreground, the end of the room is likely to be greatly overexposed and the halation of the windows extreme, so it is best to expose the plate for the middle of the room and develop with a rather weak developer, or one containing considerable bromide of potassium as a restrainer. A sable brush dipped in concentrated developer may then be used to bring out the foreground, holding the plate in the left hand, and slightly inclined, so that the developer will run toward the bottom of the plate. After manipulation in this manner, the plate should be returned to the original solution and development continued in the usual way.

Case III.—A very dark interior, such as a warehouse storeroom or a drift mouth.

The first difficulty here is in focusing, there being insufficient light to make a visible image on the ground glass of the camera. This can be overcome by the use of a candle set in different parts of the room during the adjustment of the camera. Focus to get a sharp image of the candle flame on each end and in the center of the plate, then raise and lower the light so as to determine the extent of the room taken into the angle of vision.

The most satisfactory exposure in this case would undoubtedly be the flash light, and if such is used it should be placed above and to one side of the camera and moved slowly from right to left while it is burning. This movement softens the edges of the shadows and prevents the harsh effect so prevalent in flash lights made by inexperienced operators. If the flash powder burns too fast to permit of this movement, let two flashes be used, one each side of the camera. In either case, *use plenty of powder*. The flash may appear bright to the operator, but it must be intense to satisfactorily illuminate the remote corners of a dark room.

As a usual thing, however, the owners of buildings are opposed to the use of explosive powders in their warerooms, on account of the danger of fire, and we are then compelled to get on without artificial light. If any daylight penetrates the interior at all, it can be reflected into dark corners by means of white papers or cloths hung behind the camera so as to catch the light from the source of illumination and reflect it in the desired

FIG. 4.—PRINT FROM NEGATIVE AFTER TREATMENT

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direction. A mirror about 2 feet square can also be used by the operator to throw the reflected light into very remote corners, while the rest of the room is illuminated simply by such light as naturally finds its way in. The exposure in a case of this kind might last an hour, during the first half of which the mirror could be used to reach the deepest shadows. In the development of such an interior, one must be prepared for every emergency. When flash light is used, the foreground will receive a much more brilliant illumination than the distant portions, and brush development may be necessary to get an even negative. The dangers of halation in flash-light work are also very great, as the intense flash reflected from a brass railing or piece of polished steel will produce most unexpected halos on the plate.

With the long exposure this danger is less likely, but owing to the uncertainty of the actinic value of the reflected light, there may be a great unevenness of exposure that will require strong developer in some places and considerable restrainer in others.

Case IV.—A very dark interior, with dark-colored objects, such as a coal breaker, roundhouse, or blacksmith shop.

While there would probably be no objection to the use of flash powder in a roundhouse or blacksmith shop, there would be serious objections to its use in a coal breaker, where the flying coal dust is of a somewhat explosive character itself, if sufficiently heated and ignited. Here, then, we have a problem in photography: where there is little or no light to act on the plate, where the air is so full of dust as to render distinct vision impossible, and where the vibration of the machinery renders stability of apparatus very uncertain.

To get any kind of a result under these conditions, we must first eliminate the dust. It is absolutely necessary that the cause of the dust be stopped temporarily and the dust allowed to settle. As soon as the distant objects begin to show themselves a little through the cloud, the exposure may be commenced, and then continued from 1 to 10 minutes, according to the circumstances. There are no bright surfaces here to reflect the light into remote parts, and a prolonged exposure is the only thing that will impress the gloomy details on the plate. The foreground, of course, becomes greatly overexposed, but this can be reduced by subsequent manipulation. But here another difficulty arises: long exposure and constant vibration of machinery render an indistinct, if not a badly blurred, picture; so we must guard against this element as much as possible. It is not the vibration of the machinery that causes the blur, however, but the vibration of the camera. The vibration of the details 20 feet from the camera will cause no excessive indistinctness on the plate if the camera can be kept rigid. This can only be done by placing the three legs of the tripod on supports that are not as much influenced by the machinery as the parts to be photographed. Wherever there is any masonwork, let the camera stand on that. If the side walls contain any masonry, let one leg of the camera rest against that wall, and, in any case, select points for the three legs that vibrate as little as possible.

During a long exposure the dust in the air will not materially affect the picture unless there are streaks of sunshine through it; workmen or other individuals passing or repassing in front of the camera will do no harm if they do not stop and stand in the field of vision; and the timbers and other details in the remotest parts of the picture will come out more clearly and distinctly than they can be seen with the naked eye.

The two illustrations, Figs. 3 and 4, were made from two photographs taken from the same negative. The subject is the interior of a coal breaker, the timbers of which were dead black, and the details in the distance so indistinct as to render focusing almost guesswork. Through the side windows came streaks of sunlight that not only made white patches throughout the picture, but caused an halation that obscured nearly all the surrounding detail, as shown in Fig. 3.

After the negative had dried, it was cleaned of its halo as follows: The dense spots were *painted* with plain water, applied with a camel's-hair brush, and allowed to soak thoroughly into the film. The whole negative was then immersed in a reducing solution, as heretofore described, and the soft part of the film being more susceptible to the action of the chemical than the dry part, the reduction takes place there more rapidly, thus presenting on completion a negative that will print as shown in Fig. 4.

When a portion of a negative is to be reduced, the main difficulty is to effect that reduction without leaving a line between the denser and thinner parts of the plate. This can be accomplished in nearly all cases as explained above—first wet the spots to be reduced, and then reduce the entire plate. Should the reduction be carried too far, the plate may be intensified evenly all over.

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THE GREAT MINERAL-PRODUCING COUNTRIES

SOME interesting statistics concerning the output of the more important minerals by the great mineral-producing countries of the world are given in the "Blue Book" by Prof. C. Le Neve Foster, published by the British Home Office. In the matter of coal production, Great Britain, in 1897, led the United States by 20,000,000 metric tons, and in the same year the United States exceeded by 2,000,000 tons the iron production of Great Britain. The diagrams shown are reproduced from Professor Foster's report, which covers a period of twenty years, from 1878 to 1897, inclusive. Fig. 1 gives the annual output of coal of six of the principal coal-producing countries during this time, while Fig. 2 shows the annual output of iron of nine countries during the same period.

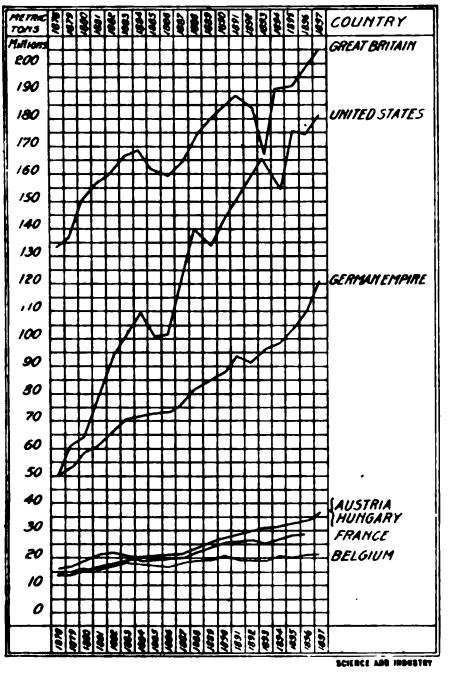

FIG. 1

In coal production, Fig. 1 shows that in 1878 Great Britain led the United States and Germany by more than 80,000,000 tons, and that in 1897 Great Britain and Germany had each increased their annual output only about 70,000,000 tons, while the increase of the United States was 130,000,000 tons, making the total output only 20,000,000 tons less than that of Great Britain.

Fig. 2 shows that, in iron production, Great Britain in 1878 occupied the leading position, with an annual production of 16,000,000 tons, and, at the end of the time covered by the report, had dropped to second place, with an annual production of 2,000,000 tons less than at the beginning of the period; the United States, at the beginning of the same period, occupied second place, with an annual production of 4,500,000 tons, and at the end of the period occupied first place, with an annual production of 16,000,000 tons, or the same amount as was produced by Great Britain at the beginning of the period. The diagrams show the relative importance of the other leading countries so far as the production of coal and iron is concerned.

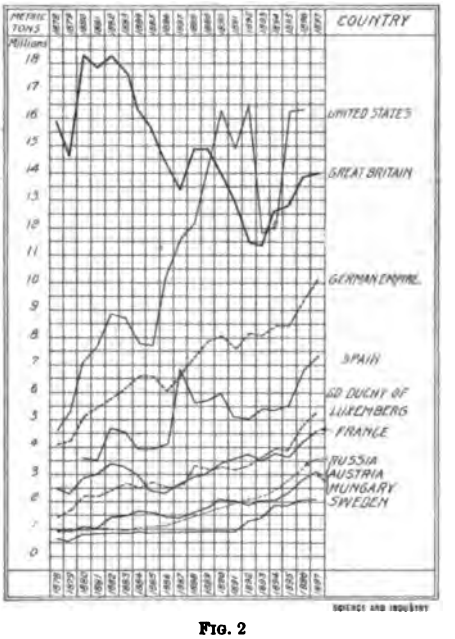

FIG. 2

In the matter of the output of gold, the United States occupies the first position, but the statistics show that in 1897 the South African Republic had almost succeeded in overtaking the United States in the output of this metal, and the indica-

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tions are that the Transvaal may even yet become the leading gold producer of the world.

The only great copper-producing country is the United States, with an annual production of 223,000 tons, which is considerably more than half of the world's output. The next greatest amount was the joint output of Spain and Portugal, which was about one-eighth of that of the United States.

The greatest lead-producing country is Spain, which slightly leads the United States, while Germany is third on the list.

The only great silver-producing countries are the United States and Mexico. Australia has an annual output of about one-third that of the United States.

LIQUID AIR AS A BLASTING AGENT

ALREADY a reaction has promptly set in against the exaggerated opinions on the prospects of liquid air in which the press indulged; the difficulties that the application of condensed gases of so low boiling points involves do not appear to be well understood. Some experiments, conducted by the Vienna Crystal Ice Co., in the presence of representatives of the Austrian Technical Military Committee, may, therefore, be of interest. These experiments are by no means decisive, since they were certainly not made under favorable circumstances; but they are instructive. The liquid air was obtained from the Linde Co., in Munich, and was transported in open flasks provided with a Dewar vacuum jacket. The flasks were packed with felt and cotton; over the open neck, which projected through the lid of the wooden case, a cap of felt was loosely fitted. When despatched, the liquid contained a mixture of oxygen and nitrogen in the ratio of 75 : 25. During the 72 hours that elapsed before actual use, the greater part of this time being spent in transport, half of the liquid had evaporated, and the remaining liquid contained 85 per cent. of oxygen; nitrogen is more volatile than oxygen. Two kinds of cartridges were made of kieselguhr, mineral oil (solar oil), and the liquid. In the first case, the kieselguhr and oil were mixed in a wooden basin, the liquid added gradually, and the paste ladled in paper cartridges clothed with asbestos. In the second case, the earth and oil were charged into the cartridge, which rested in a double sheet-metal cylinder with a separating layer of felt, and the liquid air gradually poured into the cartridge until the mass was thoroughly impregnated.

In both cases the formation of mist and of hoar frost sufficiently indicated how much of the oxygen escaped during the preparation. The cartridges could be handled, but the men did not care to squeeze them in firing the primers and detonators; as a consequence, one cartridge missed fire. Holes 30 inches deep were bored in rock. It resulted that these so-called oxylignit cartridges were hardly strong enough, as too much oxygen had evaporated. The cartridges of the second type did not prove so powerful as the others, probably because the lead cases furthered evaporation, especially from the bottom of the cartridge. On these results, Artillery General-Engineer Hess has commented to the following effect: The preparation of the cartridge is wasteful and dangerous to the eyes, etc., and, owing to the rapid evaporation, it is further impossible to guarantee the strength of the cartridge, even in the roughest way. Kieselguhr and oil seem to be suitable absorbents, and oxylignit an effective blasting agent, though comparative tests have not yet been made. The cartridges must be used within, say, 15 minutes of their preparation. There is no danger, hence, from missing fire. But, on the other hand, it will be difficult to fire many cartridges simultaneously, and, strictly speaking, the cartridges should be made on the spot, and be in a very hard condition. That would scarcely be possible below ground; the spiriting liquid might break the glasses of the hot safety lamps, and it remains to be investigated whether the large volumes of oxygen might not lead to spontaneous ignition of marsh gas or coal dust. The evaporating oxygen would, on the other hand, improve the air, and the blasting would not contaminate it. Some of these objections are very serious, especially the unreliability of the power of the cartridge, and the short period during which it remains active. The cartridge cannot, of course, be sealed, nor can the vessels in which the liquid air is transported. For military operations oxylignit would certainly not appear to be suitable. But the whole question is only in its experimental stage, and better methods of making cartridges could probably be devised.

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THE GEOLOGY OF THE NORTHWEST

Prof. Arthur Lakes

THE GREAT LAVA FLOWS—HORNITOS—THE GREAT TERTIARY LAKES—THE GLACIAL AGE. LAKE LEWIS—THE GRAND COULÉE—GLACIERS OF THE ROCKY MOUNTAINS

TWO geological phenomena that are of popular as well as striking interest are glaciers and ice sheets on the one hand and volcanoes and lava flows on the other. In no part of the world are the manifestations of the two great dynamic forces of nature — water and fire — more strikingly shown than in that known as the Great Northwest of the United States. This region includes parts of Oregon, Idaho, Washington, California, British Columbia, and Alaska. This vast section was at one time deluged by oceans of lava, and afterward covered with great fresh-water lakes, and huge ice sheets and glaciers.

A trip through a portion of this area during the past summer was particularly impressive, and the results of the trip we propose to describe are in line with the sketch that we endeavored to give in a preceding article of the more southern portion of this western area along the line of the Union Pacific and Central Pacific railways from Denver to San Francisco.

We encounter the first signs of one of these great phenomena, before mentioned, on the Oregon Short Line Railroad, between the boundaries of Wyoming and Idaho. Here we meet the extreme eastern border of what is known as the Great Lava Flow of the Northwest, a body of lava composed of many different consecutive layers, sheets, and flows, that with little interruption cover the greater part of Washington, Idaho, and Oregon for over 200,000 square miles, and are from 300 to 3,000 feet thick. Over this area, greater in extent than France, there are but few volcanic cones or craters to which these flows may owe their origin. What few isolated crater mountains there are, like Mt. Hood and Mt. Tacoma, are restricted to the Pacific Coast, and though the fires in these are not yet quite dead, we can in no wise attribute the vast areal flows to such limited sources. It seems more probable that the earth opened its mouth in a multitude of fissures, from which the molten floods poured like an ocean of fire in successive flows over the country, than that these vast sheets were emitted from isolated volcanic cones or craters. Although most orifices from which the lava could have come are deeply covered by the lava sheets, and all traces of the friable material of which crater cones are usually composed have been removed by erosion, yet, in a few favored spots, we actually find evidences of fissures that may have supplied the lava now filled with solid dikes of basalt.

Near Pocatello, on the Oregon Short Line, granitic mountains come down to the border of the great desert; and in the narrow valleys between these hills we find the natural watercourses filled by long flows of black basaltic rock, just as if a molten flood had poured down the valleys and driven the rivers from their natural bed, and then congealed there like the slag poured from the slag pot of a smelting furnace.

Later, in some cases, the rivers, by cutting through the lava, recovered the original river bed, and so, as we go along the valley by the side of the stream, we pass through walls of black molten rock rising in terraces of columns one above the other, on either side of the railroad track. The surface of these coulées, or lava flows, resembles the top of a honeycomb, owing to the rude symmetrical cracks outlining the divisions between the polygonal columns of the lava sheet, which resemble those of the Giant's Causeway or the Palisades of the Hudson. These cracks, as well as the columns, are caused by the cooling and contraction of the lava in much the same way that cracks are formed in the muddy bed of a pond that is drying up. They descend vertically through the lava sheet, and outline and define the forms of the pillars or columns that are so strikingly characteristic of basaltic formations. Between one lava sheet and another there is often a little terrace formed of rough, spongy, cindery lava. This originated from the froth, charged with steam, on the top of one lava sheet before the second one was poured on it.

As we advance northward into Idaho the lava sheets become wider and more general, till at last they cover the whole region, and form a vast repulsive desert of black molten rock, barely clothed with sage brush. In the distance, a few sharp-cut volcanic-looking

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mountains break the monotony. In the near foreground, the undulating masses of black rock are here and there diversified by small rough cindery-looking cones from 10 to 30 feet in height, hollow in the center and breached on one side, as if they had split open from some cause and discharged their contents. They look like miniature craters on the great lava plain. Originally, they were blisters or bubbles charged with steam, and their peculiar form results from the explosion of the steam. Doubtless they emitted fire, smoke, and lava, like little volcanoes, until the steam was exhausted. These miniature volcanoes on the lava flows of Vesuvius are called by the natives *hornitos*.

We are glad when night throws a veil over the dreary scene, but even when we awake next morning, in the pleasant meadows and valleys of Oregon, the same rock confronts us by the roadside, and continues with us, with few exceptions, to the end of our journey through the Northwest.

The scenery produced by cliffs of these singular columnar rocks, where the Snake River or the Columbia cuts a cañon down through them for several hundred feet, is often very striking, and throws the celebrated Palisades of the Hudson into the shade. Often there is a vertical cliff of regular columns, 100 feet high, rising above the river, surmounted by a terrace and another row of columns, and so on to the summit. The columns are not always of the same size, nor do they always point in the same vertical direction. Near the summit, especially, they may be very small, only a few inches in diameter, and point in every direction, like a fan. As many as 608 layers of columnar lava, each from 50 to 150 feet thick, have been observed on the walls of the Columbia River.

A vertical dike of this basaltic rock, filling a fissure that is cut through other formations, may resemble a row of piled-up cord wood, the columns being horizontal, and the cracks having formed the pillars at right angles to the cooling surfaces, which were the walls of the fissure. These dikes are rarer than the sheets. As we approach the descent to the Columbia River near Wenatchee, the columnar cliffs on each side of the cañon are very conspicuous, and as the green waters of the river wind among the black lava boulders and across the dreary country, we might imagine ourselves in the mountains of the moon, so bleak, so weird, so desolate is the scene.

Monotonous and uninviting as is the appearance of this singular, molten, black rock, it has its redeeming qualities. It readily decomposes on the surface into a rich black soil, the decomposition being facilitated by the fact that moisture has access to the cracks between the pillars and to the spongy "lava froth" of the surface flows. The minerals, too, composing the rock are not only more or less easily soluble, but contain lime and phosphates and other elements conducive to the formation of a rich soil. To this geological structure, with its attendant surface decomposition, may be attributed the fertility of the country around Vesuvius and Etna, in Europe, and the billowy grain fields of Oregon and Washington, in the United States.

The rock makes good road metal and fair building stone. Spokane, the frontier city of the Northwest, is built upon terraces of this lava, and many of the houses are constructed of it. Curiously enough, though the precious metals are usually connected with volcanic eruptions, these vast basaltic flows are remarkably destitute of metals of any kind.

The cause of these great lava flows was doubtless due to some upward movement of the great Rocky Mountain system, the terrible straining force of which produced great fissures, from which the fiery flood poured. The lava eruptions appear to have begun about the close of the Cretaceous, or Mesozoic, period, continuing on into the Tertiary, and, in a minor degree, into the Quaternary, and in our modern crater volcanoes, even up to today. The disturbances and eruptions were not confined to the Northwest, for all through the center of Colorado there are dikes and lava flows that culminate in a huge lava plateau in the San Juan Mountains, covering many hundreds of square miles in Southern Colorado. The same eruptions are continued at intervals in Arizona and New and Old Mexico, and along the eastern flanks of the Rocky Mountain Range.

The next event that happened to the great lava flow was that its surface was covered with a vast lake, or fresh-water sea, as if to quench effectually its latent heat. This fresh-water lake covered a great region of central Washington and Idaho, and the traces left by it on the banks of the John Day River, of Oregon, have led geologists to call it the John Day Tertiary Lake. The bed of this lake is found to be composed entirely of minute volcanic dust and débris,

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which must have been ejected from explosive volcanic vents in the vicinity, and fallen in showers into the lake till a thickness of a thousand feet accumulated on the bottom.

Sections and terraces left by this lake on the flanks of the Cascade Mountains and on the so-called "White Cliffs" of the Columbia River show the material to be soft and friable, but at times, by pressure, it is hardened into the consistency of building stone. These beds entomb the fossil remains of many large and strange prehistoric mammals, together with the fossil-leaf impressions and trunks of trees of a semitropical vegetation that once grew around the edges of the lake. In time, this great body of water drained off, leaving its beds of sandstone covering the lava.

The next event that occurred was a general disturbance of the region, by which the lava sheets with their overlying lake beds were uplifted in great blocks, and what is now known as the Cascade Range was formed. These uptilted blocks of country are surrounded by innumerable and deep faults, and show steep cliffs, or fault escarpments, the line or fissure of the fault running along the base of the cliffs. Subsequently these mountains have been modified by landslides on a grand scale, due to the heavy lava beds resting on layers of more friable material. In these landslides are often found the fossil trunks of prehistoric oak and pine trees.

Long after the great lake was drained and its bottom upraised into mountains, and after deep cañons had been cut in it by rivers, a third event happened. The climate, which had hitherto been mild or semitropical, gradually changed as the ice sheet of the glacial epoch set in from the north. Every mountain amphitheater became filled deep with snow, which was packed by pressure into "snowball" ice, or, as the Swiss call it, *névé ice*. This evolved into clear blue glacial ice, which began to descend from the mountain amphitheaters down the cañons, moving slowly, partly by down-hill pressure, and partly by a peculiar process of minute fracture and alternate thawing and freezing. The thickness of these ice masses may be judged from the marks left by one of them on the walls of the great depression, the lower portion of which is occupied by the present Lake Chelan. This depression was 100 miles long and 3,000 feet deep, the last 500 feet being below sea level. Marks are found on the cliffs showing that it was filled throughout by a glacier 3,000 feet thick.

These huge masses of ice greatly enlarged, deepened, and widened the original cañons through which they passed, and broadened them from the V shape cut by the stream to their present broad U shape. The rocks on the sides and bottom of the cañon were scored, grooved, rounded, and polished; and débris from the frost-cracked cliffs falling on the ice was carried along on its surface in long moving trains called *moraines*. These fragments may be any size; we measured one at Wenatchee that was 70 feet long, 60 feet wide, and 25 feet high—larger than a good-sized log cabin.

On reaching the terminus, or end of the ice, the blocks rolled off, forming a crescent-like bank or moraine thrown across the cañon. When the glacier retreated by melting, this moraine, by obstructing the drainage of the cañon, caused a lake to form back of it. In this way was formed the singular winding river-like Lake Chelan, filling the deepest portion of a cañon 1,500 feet in depth, 65 miles in length, and in width rarely exceeding 2 miles and often only a few hundred yards. Into the green depths or dark abysses of this lake the ground and polished faces of the cliffs of the surrounding mountains plunge abruptly, with deep water close to the water-line.

A glacier also flowed down the valley now occupied by the Okanogan River, and, on reaching the Columbia, turned that river from its course and filled the cañon, 2,400 feet deep, brimful with ice, and then overflowed and crossed it, continuing on its course without deflection to the great plain of the Columbia, scattering lava boulders on its way over the plateau. Its southern limit, according to Mr. Israel Russell, to whose researches we are indebted for our knowledge of the glaciation of this region, was the site of the present Coulée City, and its eastern limit was defined by the walls of the Grand Coulée itself. At the south it ended in a great glacial lake called Lake Lewis, and sent icebergs over the lake freighted with boulders, some of which came from as far north as Canada.

This Lake Lewis covered a large area of the great plains, extending south into Oregon and east to Idaho. The lake was caused by a dam at The Dalles; a glacier also probably obstructed its drainage. It was 1,000 feet deep, and left terraces behind it on the hillsides marking its former level. It existed at the time of the greatest

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extension of the glaciers, and was fed by their melting.

Over the Columbia plain are scattered huge boulders of granite and basalt, dropped from icebergs floating out on the lake. The great glacier, carrying boulders over the southern border of Douglas County, came from the north down the broad valley now drained by the Okanogan, and crossed, as we have said, the cañon of the Columbia without turning from its course. On reaching the southern wall of the cañon, formed of basalt resting on granite, a cliff arose to a height of 2,500 feet athwart its course. This it overrode, as shown by the scoring on the rocks, and continued on to Coulée City and ended in Lake Lewis. The glacier, as it overrode the cliff, carried off the lava cap and scattered its débris over the plain for 50 miles.

One of the most striking and remarkable features of this region is what is called the coulées, of which the Grand Coulée is the best example, and reveals the history of these singular avenues of basaltic cliffs. The Grand Coulée is 4 miles wide, and consists of a flat-bottomed valley, now occupied by farm lands, between vertical walls of basalt several hundred feet in height. The bottom of the valley is 500 feet above the valley of the present Columbia River, and the descent into it is by a precipice of basalt over which a great cascade once poured that cut back the cliff for half a mile. When the ice of the Okanogan Glacier discharged south, it crossed, as we have said, the Columbia Cañon, and dammed back the waters of the river, which escaped south over the precipice and down the Grand Coulée. The glacier also poured over the western wall, and, breaking off, charged the river below with icebergs that swept down the coulée and over the plain to the south, to the outlet of the gorge at Coulée City, and there dropped the boulders that still obstruct the plain.

The cañon below Coulée City is 400 feet lower than the bottom of the great gorge leading north to the Columbia. As the great river flowed through the coulée, it plunged into the cañon over a precipice 400 feet high, in a fall more than twice the height of Niagara, and wore out deep basins in the rocks below, converting them into little lakes. We can imagine how the cliff would look if the waters that pour over Niagara Falls were drained off; so that to look back over a precipice of black basalt twice the height of Niagara—over which the Columbia once poured—is a most impressive sight.

A peculiar feature observed in this region is that rivers have cut down their channels across the upraised volcanic blocks of mountains as rapidly as the volcanic ridges were raised by faults occurring athwart their course. A river that once gains a right of way is bound to keep it, no matter what obstructions are raised in its path. The higher the mountain rises, the deeper the river cuts.

Such are some of the remarkable phenomena of this remarkable region, but besides the traces of the gigantic forces of the past, there are still some diminished representatives of them existing in the neighborhood. At one time it was thought that we had no glaciers in the Rocky Mountain system, at least none comparable to those of the Alps, but later researches have discovered several quite or nearly on a par with those of the latter. A good-sized glacier was first discovered by the Hayden party in the Wind River Mountains of Wyoming; later, quite a number of glaciers of various sizes have been found in the Sierras; and lately we saw the diminished relics of the great Chelan Glacier still clinging to the summits and upper cañons of the Cascade Mountains above the old glacial Lake Chelan; and in the cañons in that vicinity the glacial marks on the smooth rounded walls are so fresh as to impress one with the idea that it is only a comparatively short time since the glaciers vacated them.

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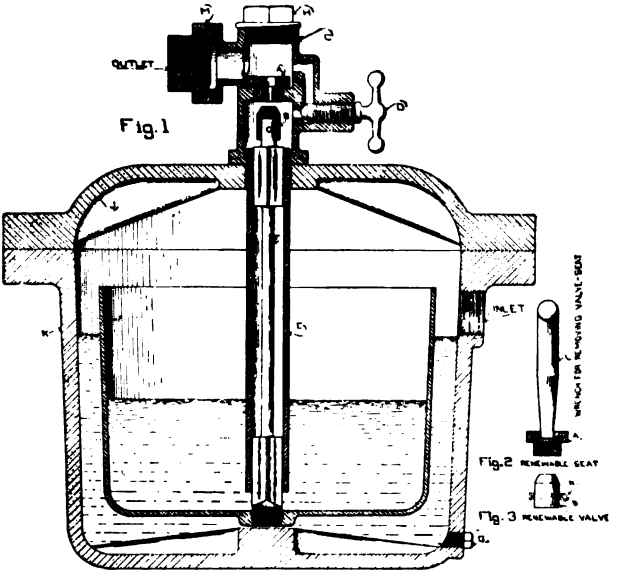
THE INSIDE OF A STEAM TRAP

How the Water Is Allowed to Escape Automatically, While Steam Is Held Back. The Use of the Floating Bucket

STEAM traps are used for the purpose of automatically draining water of condensation from any pipe or vessel containing steam, without allowing the steam to escape. They are invaluable in the steam-engineering and steam-heating professions. For example, in steam-engineering practice they are used to automatically drain water from low points in steam mains, which, if neglected, are liable to burst a steam pipe or drive the head off the cylinder of an engine. A careful engineer will never start an engine without first draining all water out of the steam main and the cylinders. But engineers, even, have been known to forget things, and plugs of water have, consequently, been blown into engine cylinders, to the detriment of the engines, causing considerable expense to their owners.



In the steam heating trade, steam traps are in great demand. They are used to automatically drain water of condensation from steam radiators and their distributing pipes. For example, the exhaust steam from an engine, combined with a little live steam from the boilers, is used to heat a building by means of radiators and pipe coils. All the condensation water flows through "return pipes" to a central spot, where these pipes connect to a steam trap. This trap allows the water to drain away from the heating system into a hotwell, from which it is pumped back to the boiler while hot.

A certain penny-wise and pound-foolish steam engineer's opinion was asked regarding the installation of steam traps in an addition that was being built to the plant already under his charge. "Well," he replied, with an assumed thoughtful expression that he must have cultivated from boyhood, "what's the use of going to the expense of putting in steam traps when a drip pipe with a valve on it will drain the water off? I can easily throttle down the valve and set it so that the water will run off just as quick as it gathers."

It is needless to say he got a chance to do it. He erred on the safe side at first, by allowing the drip pipes to blow steam, but the proprietor informed him that such a waste of steam could not be permitted, so the ignoramus throttled down the valves on the drip pipes until nothing but water came out. He did not consider the fact that the amount of condensation water to be removed from the system is variable. The result, of course, was quite natural—he blew an elbow on the steam main to pieces and nearly scalded himself to death. When he recovered he recommended steam traps.

There are lots of different kinds of steam traps on the market, but it is questionable whether any are much more suitable for general work than "The Albany Trap," an illustration of which is shown in the accompanying figure. The condensation pipe connects to the tapping marked *inlet*, and the pipe intended to discharge the condensation water after it has passed through the trap, connects to the coupling tail marked

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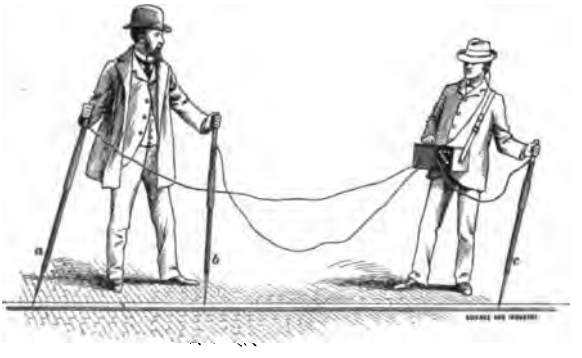
outlet. Water and steam together flow into the outer casting, and surround the bucket. As the water fills the chamber, the bucket, being empty, floats, and thus rises with the water, and the valve *B* is pressed up against its seat. The trap is then closed, and neither steam, air, nor water can escape, unless the by-pass valve *D* is open, which, when the trap is in action, should always be shut. When the water of condensation rises high enough to overflow the floating bucket, this vessel soon fills up and loses its buoyancy, when it sinks and opens the outlet valve again. The steam pressure bearing down on the surface of the water in the bucket now forces this water up the tube *E*, through the valve opening at *A*, and into the outlet pipe. But, when the water is nearly all forced out of the bucket, this vessel becomes buoyant, as before, and, rising, closes the valve again. This operation is repeated while the trap is in action, and you can easily see how water is automatically permitted to escape while the steam is held back.

Fig. 2 shows how a special wrench is employed to remove the valve seat through the screw-cap opening at *H*. Fig. 3 shows how the valve is attached by a split pin that allows it to swivel, and thus adapt itself to the valve seat. The plug *G* is used to drain the trap body and prevent it from freezing during cold weather, when it is not in use.

TESTING RAIL JOINTS

A NOVEL method for testing the resistance of street-railway track joints is shown in the accompanying illustration. The operator on the left is provided with two poles having pointed metal terminals. Flexible wires lead from these terminals to the box carried by the second operator, who also carries a similar rod connected to the



box as shown. This box contains an interrupter that interrupts the current flowing through the head telephone worn by the operator, and thus causes the telephone to make a noise. Poles *a* and *b* are placed about 3 feet apart, so as to span the joint and fish-plate. Pole *c* is placed about 4 or 5 feet from *b*. By means of the switch the telephone is thrown first across one span and then across the other, the pole *c* being shifted until the sounds obtained for the two different positions are nearly the same in loudness. The switch on the box is then thrown to the middle position and the position of *c* more accurately adjusted, until little or no sound is heard in the telephone. When this condition of affairs is reached, the resistance of the length of rail between *b* and *c* is equal to the resistance of the joint between *a* and *b*. Since the weight of rail per yard is known, the resistance of the joint may be calculated from the known length *b c*. Usually, however, this would not be necessary, because the test is used principally for locating bad joints, and comparative results are what are looked for more than absolute measurements.

It will be noticed that the above test makes use of the current flowing in the rail, but is independent of the variations in this current, because the same current flows through both rail and joint. The use of the telephone instead of a voltmeter allows the tests to be carried out conveniently and rapidly. It is claimed that this method of testing has been used quite successfully throughout New England.

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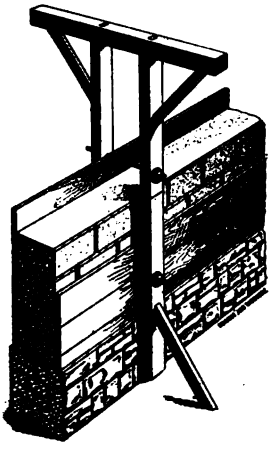
USEFUL IDEAS

BUILDING CONCRETE WALLS

J. J. B., Elizabeth, N. J.

A SHORT time ago I saw a building constructed of concrete; and, as such work is somewhat unusual in this country, a description of the method employed might be of interest to your readers. The building was erected in this city for The Standard Oil Company. The work was in the nature of an experiment, and two methods were employed. They first put up posts as high as the first story, and then planked up inside the posts to a height of 4 feet, the space between the planks being the thickness of the wall. The concrete was tamped in the plank mold to the top, and the planking then carried up another 4 feet, and so on until the wall was one story high. The carpenter then put in the floorbeams, and for the rest of the building they tried another scheme.



Brackets about 6 feet high were made, such as shown in the sketch. These brackets were set on the wall, plumbed up, and braced, and the planks set inside and fastened. Then the concrete was tamped in. After the concrete was well set, the bolt at the bottom was drawn out, leaving a small hole in the wall, and the brackets and planks were removed. The brackets were then braced on top of the finished wall, as before, and the operation was repeated.

I do not know whether or not the four stories were built in this way; but, as each layer must set before the brackets can be raised, the operation is a rather slow one.

[We would be pleased to hear from other subscribers that have had any experience with concrete building construction. Our own experience has been that not more than a 12-inch layer should be deposited and lightly tamped in place at one time; this should be allowed to set well before the subsequent layers are put on. There is no "hurrying up" of concrete construction in the category of good work.—ED.]

A GOOD HARDENING COMPOUND

August Mauksch, Springfield, S. D.

IN HARDENING small tools, some of the more delicate and essential parts of the tool to be hardened are very apt to be overheated and burned unless extreme care is used. For a long time I have used the following compound to prevent overheating, which will give satisfactory results if used with reasonable care. I dissolve 2 ounces of Castile soap in enough soft water to make a thin paste, and add the contents of a 5-cent package of lampblack, mixing it well into a stiff paste. This compound is to be kept in a tightly covered can.

When hardening a small tap, for instance, I slightly warm the tap and then smear the paste all over it. When dry, I heat and quench in the usual way. When the tap comes out of the hardening bath, it will be found clean enough to observe the color in tempering. Furthermore, the paste between the teeth, being a poor conductor of heat, has prevented them from becoming hotter than the body of the tap, and also prevented cooling while transferring the tap from the fire to the water. As a consequence, the degree of hardness is more uniform.

I use the same compound for small springs, lathe tools, cones of bicycles, and similar work, and have always obtained great satisfaction from it.

GAUGE FOR READING SMALL CHANGES IN PRESSURE

A Schemer

A READER from Pittsburg, Pa., sends us the following description of a method for modifying an ordinary pressure gauge so that smaller changes in pressure can be read than is practicable with the usual construction. In order to make it possible to determine the level of the water in the reservoir of a certain water works, a pipe leading from

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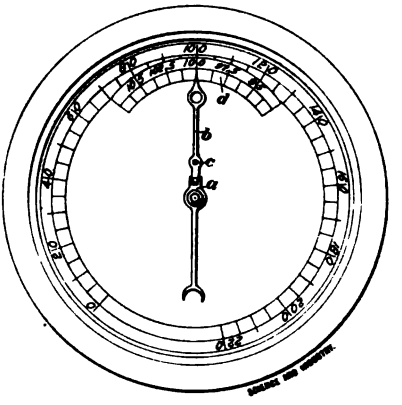
the reservoir was fitted with an ordinary pressure gauge. It was found, however, that the gauge could not be read as closely as it was desired to regulate the level of the



water in the reservoir. In order to secure the desired result, the motion was compounded, so as to increase the distance moved over by the pointer. The regular pointer was replaced by one having a forked end (see *a* in the figure). This fork fitted over a pin in the short arm of a second pointer *b* pivoted at *c*. A paper scale *d* pasted on the dial and graduated by trial completed the change and produced a gauge by means of which the level of the water in the reservoir could be determined with the required degree of precision. With the gauge changed as shown in the figure, the pointer *b* turns to the left as the pressure increases, instead of to the right, as would be the case with the regular pointer; the graduation on the supplementary dial must therefore read in the opposite direction to that of the regular dial. The center of the supplementary dial is at *c*, the center of the pivot of the pointer *b*.

The simple pin and forked-end connection between *a* and *b* confines the range within which *b* can move to narrow limits; it also makes the rate of motion of *b* variable for a given change in pressure, thus making the spaces of the graduation on the supplementary dial unequal in length. For the narrow range of pressures to be considered in the present case, these limitations and irregularities made no practical difference in the usefulness of the instrument. If, for any purpose, it should be desirable to secure a greater range of motion, and a uniform spacing for the graduations on the supplementary dial, the simple fork and pin might be replaced by a sector and pinion.

LIGHTING GAS STOVES BY ELECTRICITY

Geo. J. Nuennekens, Milwaukee, Wis.

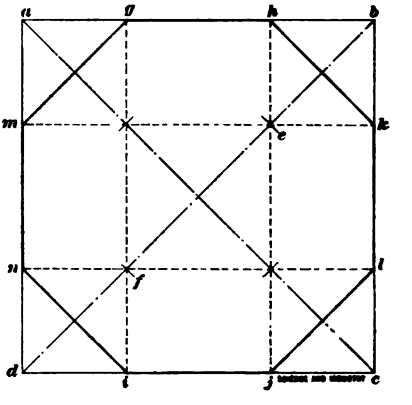
I SUBMIT to you an electrical device for lighting gas stoves. This device I rigged up for my own use at home, and found it convenient and saving.

Procure a piece of 14-gauge insulated copper wire from 8 to 10 inches long, a curling iron, and a few feet of insulated wire such as is used for swinging incandescent lights. I run the 14-gauge wire along one side of the curling iron, and, with one end bent to an ellipse, I arranged it so that when the handles were pressed together the wire would rub against the metal on the other side of the curling iron. By connecting one of the light wires to the iron and the other to the 14-gauge wire, using string or tape to hold the wires in place, I was ready to connect to the battery. The battery consisted of two ordinary cells of the carbon, zinc, and sal-ammoniac type, and in connection with an induction coil produced a good spark. By this arrangement the fingers are not near the flame, and the liability of having them severely burnt, as often occurs when the ignition of the gas hangs fire, as it were, is entirely done away with. From an economical point of view, this arrangement saves much gas and many matches.

ANOTHER METHOD FOR DESCRIBING AN OCTAGON

C. W. Meyers, East Sandy, Pa.

I NOTICE in the January issue of SCIENCE AND INDUSTRY a method of laying out an



octagon. Another way is to describe a square as *a b c d*, drawing the diagonals *a c* and *b d*, and make *e d* equal to *d a*, and *b f* equal to *b a*. With the gauge, set off the distance *a g* or *a m*, draw lines parallel to

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the four sides of the square, as shown dotted, and thus *g*, *h*, *k*, *l*, *j*, *i*, *n*, *m* will be the points through which the octagon may be framed.

PREVENTING VIBRATION OF FLOORS

W. H. Wakeman, New Haven, Conn.

In some shops and factories the vibration due to unbalanced machinery does not seem to be objectionable, provided it does not shake the rafters down, but in other places it cannot be tolerated. In a certain manual-training school, where machinery is operated on one floor and laboratories are located on the floor above, it was necessary to run a shaft at right angles to the main-line shaft, and an Almond quarter-turn coupling was used to transmit power "around the corner" (see Fig. 1). It is a very neat contrivance for this purpose, and, when in place, was viewed with much satisfaction by the men that put up the machinery. After it had been in operation about 15 minutes, a visit was paid to the laboratories above, when it was discovered that the excessive vibration was shaking bottles from the shelves. The first step to remedy this was to remove the driving pulley from the main-line shaft and replace it by a smaller one; the driven pulley was also changed so as to keep the speed of driven shaft constant. This made a great improvement, but still there was too much vibration for comfort, and the following plan was resorted to.

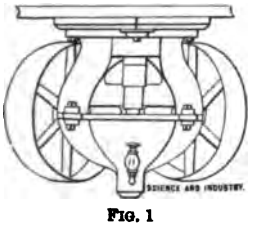


Fig. 1

The nuts on the bolts that held the timbers supporting the coupling to the

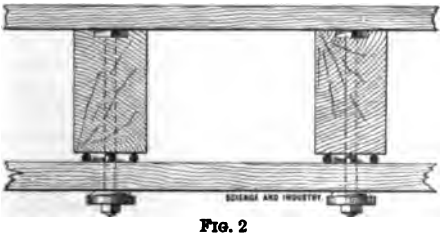


Fig. 2

floorbeams were slackened so that pieces of rubber could be put between the two timbers (see Fig. 2). The nuts were then taken off, the common washers removed, and others of a special type put in their places (see Fig. 3). Pieces of rubber tires were coiled inside of these washers, and, when put into place, the stringers to which the coupling is bolted are held between two rubber springs, or buffers, wherever a bolt is used. Solid rubber tires formerly used on bicycles were cut into proper length and utilized for this purpose. This scheme proved very effective, as the vibration was almost entirely eliminated.

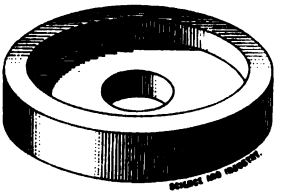
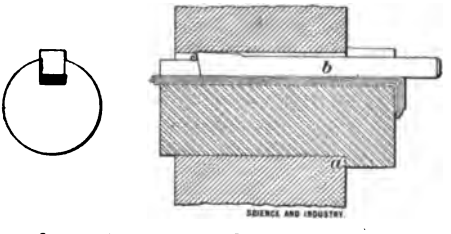


Fig. 3

SLOTTING KEYWAYS WITHOUT A SLOTTER

Fred. W. Wild

Having recently seen an inquiry as to how keyways can be slotted in the hubs of pulleys, etc., when no machine is available, I think it may be of interest to machinists to learn of a way of producing a true keyway in a hub without the use of a machine. This method has been employed by me in a



number of cases, and works very well. Take a piece of iron or steel a little longer than the hub to be slotted. Turn it down for a length about equal to that of the hub to fit nicely in the bore, forming a square shoulder at *a*. Now cut a slot *b*, equal in width to the width of the key, and of a depth about equal to the width of a key. Make a cutter, or broach, to fit nicely into this slot, relieving it as shown back of the cutting edge. Insert the mandrel in the hub to be slotted; turn until the slot is in the right position, and insert the broach from the large end of the mandrel. With a heavy hammer, drive the broach clean through the hub, thus taking the first cut. To raise the cutting edge sufficiently to take another chip, insert a strip of thin sheet tin in the bottom of the slot. Bend one end of this strip at right angles, and let it form a stop against the large end of the mandrel, thus preventing the strip from traveling

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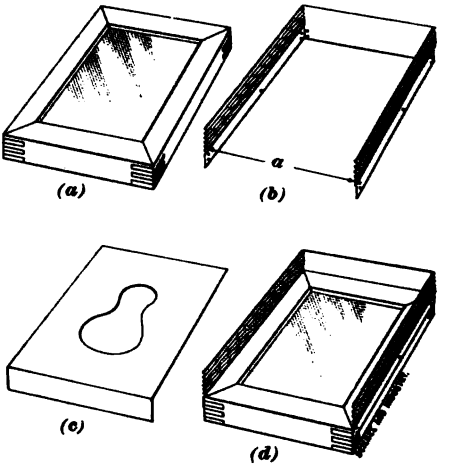
with the broach. Repeat, packing up and driving the broach through the hub until the keyway is slotted to the required depth. A little thought will show that the slot in the mandrel determines the course of the keyway in the hub. Hence, care should be taken to have it cut in a plane passing through the axis of the mandrel. If the keyway is to have draft, simply cut the bottom of the slot in the mandrel at the inclination corresponding to the required draft.

A PRACTICAL VIGNETTER

Ernest W. Maw, Milwaukee, Wis.

I ENCLOSE herewith a sketch and description of a vignetting frame, which I hope is of sufficient interest to appear in the columns of your magazine. In the accompanying figure, (*a*) shows an ordinary printing frame on which may be fastened the vignetting frame shown in (*b*). This second frame is made of metal—tin is good enough—grooved on both sides, half way down from the top, running the length of the frame. The end *a*, in (*b*), is open to receive slides having cut-outs, or vignettes, each slide having a cut-out to match the plate in the printing frame.

The slide is made about 1½ inches longer than the frame, and the part extending is bent down at right angles, to shut out the light from the open end of the vignetting frame. The slides are best made of tin, but good stiff cardboard answers as well. The grooves in the sides of the vignetting frame enable the user to raise or lower the slide, according to the blending required on the print. If it is desired to have a sharp cut-off in blending, the slide is placed close to the printing frame. A soft gradual blending is obtained by moving the slide upwards from the frame. Any size or



shape of cut-out can be made in the slides, and kept on hand for future use.

The writer has used one of these and finds it superior to cut-out boxes and other vignetters thus far invented. (*d*) shows the printing frame with the vignetting frame attached.

EDITORIAL COMMENT

THE "LITTLE BLUE BOOK"

THIS is a neat, compact pocket volume containing the time tables of all the railroads in Pennsylvania, and should be in the possession of every traveling man, hotel, business man, and business firm in the state. It is published monthly, with all corrections up to date, at $1.00 a year. Single copies, 10 cents. Mailed on receipt of price. Address, "Little Blue Book," Milton, Pa.

FEDERAL BATTERY SALT

WE HAVE received descriptive matter relating to this new compound, which is intended for use in batteries. The makers claim that it is much superior to sal ammoniac, as it results in a higher voltage, saves zinc, and prolongs the life of the cell. Another advantage is that it does not crystallize or form creeping salts, which are too often a source of annoyance in sal-ammoniac cells. If the zincs are properly amalgamated, no local action takes place.

THE LONDON AND BRISTOL TRAMWAY CO.

THE Austin Separator Company, of Detroit, Mich., manufacturers of the Austin steam and oil separators, have just shipped an order for seven of their 7-inch, new pattern, Fig. E, iron, horizontal, receiver machines, for use in the immense new power plant of the London and Bristol Tramway Company, London, England, in connection with Allis engines. As this is one of the most important and complete power plants installed during the past year in Great Britain, the selection of these goods is a distinctive honor to American industry.

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ENGINEER'S POCKETBOOK

THE American Injector Company, Detroit, Mich., are giving away a "little red engineer's book" for the vest pocket. This book answers over 500 engineering problems, and is well worth a place in the pocket. They have a limited supply left, and will send them to engineers that mention SCIENCE AND INDUSTRY.

THE L. S. STARRETT COMPANY

WE HAVE received a card from The L. S. Starrett Company, Athol, Mass., that reads as follows: "We beg leave to announce that this company has been incorporated under Massachusetts laws, with officers as follows: L. S. Starrett, President and Treasurer; F. A. Ball, Vice-President; F. E Wing, Clerk. We wish to thank the mechanics and dealers whose patronage and good will have made this business the largest in the world devoted exclusively to the manufacture of fine mechanical tools, and assure them that we shall spare no effort to merit a continuance of their friendship and support."

RAPID-ACTING VISES FOR WOOD WORKERS

THERE is more than one way of spelling *vise*. For instance, it may be *vice*. When spelled thus it sometimes means all that is bad. When spelled the other way it means a clamping device, which may be good or bad. The bad vises are not worth mentioning, but about the good vises, manufactured by W. C. Toles & Co., and which are illustrated in our advertising columns, we have a few words to say. In the first place, they are rapid-acting. This means time saved, and time is money, and a dollar saved is a dollar earned; so you see how important it is that they should have this quality. They must be strong; this is the second consideration, but not the least. How are they made strong? Well, in the same old way in which the deacon "built the one hoss shay."

"'Fur,' said the deacon, "t's mighty plain
Thut the weakes' place mus' stan' the strain;
'N' the way t' fix it, uz I maintain,
Is only jest
T' make that place uz strong uz the rest.'"

They fulfil the conditions imposed by the deacon, at least so nearly so that they will last a lifetime. Anyway, it will not matter to the purchaser whether or not they do, for they are fully guaranteed, and W. C. Toles & Co. will make good any defects at any time, free of charge.

If you are interested in these vises, which you should be if you are a wood worker, you would like to know about their construction, and the following, which, although it may not read like a patent specification, is just as clear, will enlighten you.

The screws are 1¼ inches in diameter, having square double threads, ½ inch pitch. They have a groove their entire length that fits a long, sectional, bronze nut. This construction allows an instant adjustment from 0 to 12 inches. No stronger grip can be had than by a screw. The sides are ⅞ inch diameter, cold-rolled steel, and will stand the full pressure of the screw. The jaws are cast iron, strong, and heavily ribbed. They cannot be broken, and will stand the hardest kind of use. The back jaws are fastened to the bench with four No. 20 wood screws, making a solid fastening. The front jaws have four drilled holes for fastening on maple facings, if desired.

The No. 20 is their standard vise. The No. 25 is of the same construction with the addition of a bench stop, which consists of a 1-inch square brass dog, raised by steel springs and held in position with a ½-inch setscrew. The No. 35 is a tail-vise, and is far superior to any wooden vise. The No. 40 is a valuable tool, combining a tail-vise, a bench stop, and a head-vise. By means of a dog in the front jaw, work may be held the full width of the bench.

So you can see that Toles vises are well made—very well made—and so convenient that every one that has used them is satisfied. One man refused to purchase this vise. He said he had 100 vises of another make in his shop, and if he bought one of these there would be only one contented man in the shop—they all wanted one.

UNION-MADE CLOTHING

IN THESE days of cheap and shoddy goods it is refreshing to find a firm that has built up a large and profitable business by methods that are alike just to the consumer and to the employes engaged in the manufacture of the goods. Such is the business of Hamilton Carhartt & Co., of Detroit, Mich., who 10 years ago determined to depart from the beaten paths of the sweat-shop system, and to establish a factory in which the employes should have comfortable surroundings while at work and should be paid a union scale of wages. That this commendable policy has met its just reward is evidenced by the fact that the union-made goods of Hamilton Carhartt & Co. are known over the entire country, and their qualities are such that they are always preferred to

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the cheap and shoddy goods manufactured in the sweat shops; and also by the fact that Union No. 74, United Garment Workers of America, which is composed almost entirely of employes of Hamilton Carhartt & Co., have never had a difference with the firm; on the contrary, the relations between them have always been of the most pleasant character. The advertisement of this firm appears in our advertising pages.

BOOK NOTICES

MODERN ELECTROPLATING. By J. H. Van Horne; 189 pages, 27 illustrations. Published by George K. Hazlitt & Co., Chicago.

This is an excellent book on electroplating for those that have a small plating outfit and wish practical directions for handling it so as to secure good results. It is intended, as the author states in the preface, to give assistance to those that have not had previous training in a plating establishment. The book gives full directions for preparing the work, doing the plating and polishing, and finishing the work after it has been plated. We can recommend this book to any that wish simple directions for the carrying out of various kinds of electroplating work.

ELECTRIC WIRING. Cecil P. Poole; Power Publishing Company, New York. Price, $1.00.

This is one of the best handbooks on electric wiring that we have seen for some time. The book does not aim to deal with the practical details of putting up wires, as it is written for practical men who are supposed to be familiar with this branch of their business, but who wish tables and formulas put in such shape that they will help them in their every-day work. The subject of wiring for alternating currents is treated simply and clearly, and this part will be found of special value, as it has not heretofore been treated on to any extent in wiring handbooks, most of which are a compilation of material from other works. We notice that the author, throughout the work, expresses the loss in the lines as a percentage of the power delivered at the end of the line. In most cases it has been customary to express the loss as a percentage of the power generated, which appears to be the more logical way of putting it. However, the first method seems to be coming more into use, because it is more convenient in the majority of cases, and it really makes very little difference as to which method is used, so long as it is definitely understood. We notice another statement to the effect that aluminum is coming into use for transmission lines on account of its lightness. Lightness is no doubt desirable, but is not the use of aluminum due primarily to the fact that for equal conductivity it is cheaper than copper? We doubt very much whether aluminum would have displaced copper if lightness were its only recommendation, although this, indirectly, has a bearing on its cheapness as compared with copper. The book contains 100 pages, and is bound in leather in convenient shape for the pocket.

CONDENSERS. A series of lectures and articles on the subject, reprinted from the columns of "Power." The Power Publishing Company, New York. Flexible, cloth; price, 50 cents.

This is a neat pamphlet of 79 pages, in which the subject of condensers is treated in an unusually thorough manner. The lectures and articles of which it is made up were prepared for the practical steam engineer; consequently, the subject is presented in a form that all can understand. It is introduced by an outline of the principles on which the action of the condenser is based; these principles are carefully explained and their application fully illustrated.

Following this introductory matter is a discussion on the gain in power and efficiency that may be obtained with a condenser, and of the conditions under which condensers can be profitably used. The various types are described, and practical suggestions and directions for their installation and operation, together with a discussion of their relative advantages for different conditions of service, are given. Rules, tables, and formulas for calculating the capacity of condensers, the quantity of condensing water required, and the principal dimensions of all parts of a condensing plant to meet the demands of a given steam plant, complete the work.

The simple manner in which the principles are explained and illustrated, combined with the practical instructions and suggestions, will make this a particularly interesting and useful work for the student and running steam engineer; to the designer of steam plants and machinery and the engineer in charge of their installation, the sections relating to the capacity and dimensions of condensing machinery, the practical hints regarding the best types for different purposes, and the methods of installation that will secure successful service will be of great practical value.

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ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

1. Put this address both on the envelope and at the head of the letter.

2. Only questions of general interest to our readers will be answered.

3. No questions will be answered by mail.

4. Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.

5. The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.

6. Reference to inquiries previously answered should give date of issue and number of question.

7. Questions cannot be answered in the issue of the month immediately following their receipt.

8. Any book not out of print and for sale by regular dealers may be ordered through the magazine.

9. We will not undertake to calculate windings of dynamos and motors, as this involves considerable work and is seldom justified.

In Answers to Inquiries, No. 106, March, 1900, a request was made that some of our readers give their views as to the trouble with the meter referred to. A number of suggestions have been received in response, but since some of these are repetitions, and as space will not permit of all being published, we give those that will serve to indicate the ground covered in these replies.

"The meter may have reached its limit, which is 99,900 cu. ft., and returned to start again at zero. In this case the bill would be for 82,800 cu. ft. per month, which, with natural gas used for cooking and heating purposes, would not be an excessive amount. Perhaps the meter is constructed without a 'dog,' and has been carelessly set, and is running backwards. In such a case the bill would be the difference in readings, which is 17,200 cu. ft. In either case the consumer should be willing to pay for the gas as indicated."—J. M. W., Detroit, Mich.

"When the meter was put in it read 29,700 cu. ft. This continued to increase until it amounted to 100,000 cu. ft.; then it began again at 0 and went to 125,000 cu. ft. This makes a movement of 82,800 cu. ft., which, apparently, is the amount of gas indicated. If, however, the meter has been put in backwards (the service pipe on the right instead of the left) and the check-valve does not operate, or leaks, or the clockwork at the hands is connected up backwards, then the meter is running backwards. This is not likely, but if it is the case, the amount of gas consumed will be equal to the difference between 29,700 cu. ft. and 125,000 cu. ft., or 17,200 cu. ft. If Mr. A. E. will look carefully at the two-foot hand of his meter for a few minutes while the gas is burning, he can tell in which direction the meter is running. If the two-foot hand is moving in the negative direction (opposite to the hands of a clock), his meter is running as it should; but if it moves in the opposite direction, his meter is running backwards. In reply to his second question, I would say that I do not think a gas company ever loses."—G. R. C., Seattle, Wash.

"Mr. A. E., of Buffalo, may find that his meter has been connected wrong. He should see if the inlet pipe has been connected to the outlet of the meter, which would at once explain the matter. I do not think the laws are as strict in this part of the world as they ought to be in regard to gas meters. In England all gas meters have to be sent to the inspection office (there is one in every large town), where the government inspectors test them, and, if correct, they are sealed with the official seal, which is put on them in such a way that the meters cannot be altered without breaking the seals. I have examined meters that have been used for years, and had come in for repairs, and have found them as much as 30% fast. I do not remember finding any slow ones among the old-timers, and can only think that those that did not make bills large enough were taken out and altered as soon as found."—G. H. N., Poughkeepsie, N. Y.

"A meter will not run backwards. Your reading must be incorrect, for 82,800 cu. ft. of gas will scarcely pass through a three-dial meter in a month of continuous use. If that reading is correct, you will probably pay the bill."—M. A., Brooklyn, N. Y.

* * *

(191) The accompanying sketch shows an electro-magnet designed to lift lathe turnings from pits under lathes to scrap cars. The solid lines of Figs. 1 and 2 represent original design. The core *A* is of cast iron, in one piece. A recess is turned for receiving the coil *B*, which is held in place by means of a brass plate *c*. The coil contains 850 turns of wire about ¼ in. diameter over insulation. This magnet lifts a solid cast-iron cylinder 22 in. diameter and weighing about 8,000 lb.; but it will not lift more than 75 or 100 lb. of turnings. Thinking that perhaps more polar surface might improve it, a cast-iron ring or flange *h* was attached to the original core, as shown by the broken lines. This did not improve the picking-up capacity, and the cast-iron pins *i*, eight in number, were tapped in, but with no better results. Can you suggest any improvement by which it would be possible to lift, say, 500 to 1,000 lb. of scrap turnings?

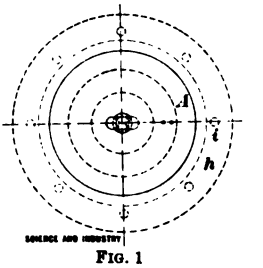

FIG. 1

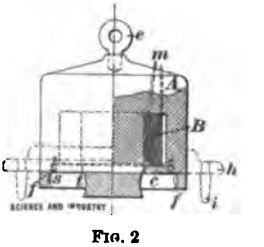

FIG. 2

P C R., Philadelphia, Pa.

ANS.—This is a point of which it is difficult to make any definite statement, but it might help matters to leave off the ring *h* and add two polar projections to the magnet. The outer one *f* may be in the form of a ring bolted to the pole face; the inner one might be of the form shown. The outer ring should have about the same area *s* on its inside face as the outer area *t* of the center pole piece. By using an arrangement of this kind it is thought that the filings will

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be held in the annular space between the poles. Extending the polar area by means of ring *h* is not likely to increase the capacity, because it decreases the magnetic density so much that the lifting power is reduced.

***

(192) The water in a cistern is stained dark from the red-cedar shingles on the roof. How can I stop this trouble? Can I do so by coating the roof with oil or paint? J. C., Philipsburg, Ont.

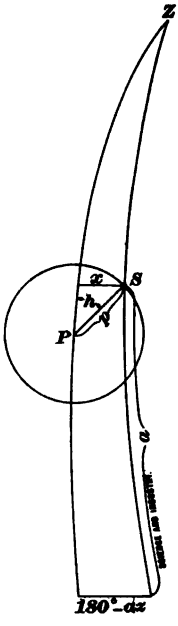
ANS.—There is no remedy that we know of to prevent the discoloration of the cistern water caused by the red-cedar shingles. The water is not made unhealthy thereby, but will very likely continue to be discolored until the shingles have been exposed to the weather for a considerable time. In our opinion it would be better not to oil or paint the roof, as we do not think it will stop the trouble altogether.

***

(193) Please give a formula for determining the azimuth of Polaris at any time when the latitude, polar distance, and the hour angle are known.

H. A. F., Mont Alto, Pa.

ANS.—Let *S* in the accompanying figure represent Polaris, *P* the celestial pole, *p* the polar distance (= 90° — declination), *h* the hour angle, *a* the altitude, and *Z* the observer's zenith. For the purpose of determining the azimuth no sensible error is committed by considering the orbit of Polaris as plane circular. We have, then, the distance of the star from the meridian *Z P*, or $x = p \sin h$. But $x : (180° - az.) = \cos a : 1$. Hence, $180° - az. = x \sec a$. In the latter formula the altitude may be substituted by the latitude. Whence, $180° - az. = p \sin h \sec lat.$



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(194) (*a*) Why are manhole and handhole covers made oval instead of round? (*b*) How would you determine the size of injector required for a given boiler? (*c*) What are the ingredients of a good boiler compound?

W. L. S., St. Louis, Mo.

ANS.—(*a*) When the joints of the manhole and handhole are made on the inside of the boiler (or other vessel), a flange must be provided on cover, thus making the overall dimensions of the latter larger than the hole in the boiler. Hence, in order to put the cover in, we have to make it oval. (*b*) Send the following data to a good injector manufacturing company, and they will supply you with a suitable injector. Tell them (1) the amount of feedwater to be injected per hour; (2) the steam pressure carried; (3) the height of lift; and (4) the temperature of the feedwater. If you have an unusual length of suction pipe, or if you feed through a heater, state the facts. You can obtain your water consumption per hour from an indicator card, allowing a liberal percentage for various losses, and drains, if any, on the steam supply—other than what reaches the cylinder; or, if you know the horsepower of the boiler, allow half a cubic foot per horsepower, say 32 lb., providing also for losses, as above mentioned. (*c*) Speaking generally, soda is, we believe, the base of all such compounds, although they are colored and doctored to give variety and to make them appear different from their rivals. Exercise care in using these compounds. You might communicate with the Dearborn Drug and Chemical Co., Rialto Bldg., Chicago, Ill. They make a special business of treating feedwaters, on a rational plan.

***

(195) (*a*) Can you recommend a good book or magazine that treats on the operation of envelope machines? (*b*) What is paper made of, and what is the process of manufacture?

P. J., Hartford, Conn.

ANS.—(*a*) We know of no such publication. The United States Envelope Co., Springfield, Mass., who controls all patents on these machines, can give you all information concerning them. (*b*) It would take more space than we can afford in these columns to give an adequate idea of the materials and processes of paper making. We can state, in a general way, however, that almost all paper, with the exception of the highest grades of writing paper, is made from wood.

***

(196) Is there any book giving dimensions required for induction coils? If not, please give following for a coil giving a 15″ spark: (1) core dimensions; (2) size and quantity of primary and secondary wire; (3) size and number of sheets for the condenser.

F. L., Montreal, Can.

ANS.—There is a book entitled "Induction Coils," by Bonney, that will probably contain the information you need. For ordinary X-ray work you would hardly need a coil giving a spark as long as 15 in. Such a coil would be large and expensive, and a 6″ or 8″ coil should answer. The price of the above book is $1.00. It can be procured from The Technical Supply Co., Scranton, Pa.

***

(197) (*a*) Does water always boil when a temperature of 212° F. is attained, or does the boiling point depend on the nature of the water? (*b*) When raising steam in a boiler, does it not have to get to 14.7 lb. per sq. in. before any pressure begins to show on the gauge? F. A. W., Poland, La.

ANS.—(*a*) Pure water boils at 212° F. with a barometer reading of 30 in., or, say 14.7 lb. per square inch. Many things affect the boiling point of water: (1) If the water is entirely free of air, it may be raised to 260° or more before boiling takes place. (2) If the water is greasy or salty, its boiling point will be higher. (3) If the pressure on the water is increased, the boiling point will be raised; if decreased, the boiling point will be lowered. Thus, a greater temperature will be attained in a mine before boiling begins than on the ground at sea level; and a lower temperature will be required on top of a mountain than in a valley. (*b*) Yes; when the tension of the vapor exceeds 14.7 lb. absolute, the index of the gauge begins to move. When the pressure in the boiler is only the same as that of the atmosphere, the gauge registers 0. When the gauge registers, say, 10 lb., the actual pressure on the inside of the boiler is 10 + 14.7 = 24.7 lb., but the effective pressure for actuating the pistons is only the excess above atmospheric pressure, so the gauge is set to show only this amount, 10 lb. in this instance.

***

(198) Please tell me how to splice a steel-wire rope 1 in. in diameter, so it will run through a block, and also the kind of tools required.

E. B. C., Lincoln, Me.

ANS.—An excellent article on how to splice a wire rope in from 20 to 30 minutes was published in the May, 1899, number of "The Mechanics Arts Magazine." It gives instructions in details and also information as to the tools required.

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(199) Explain the method of determining the wind pressure on a roof perpendicular to the slope, assuming that the wind produces a pressure of 40 lb. per sq. ft. when blowing against a vertical plane. Solve by trigonometry if possible. N. A. L., Fulton, Mo.

ANS.—The pressure created normal or perpendicular to the roof slope by the wind acting in a horizontal plane, is calculated by the formula $P^1 = P \sin i^{1.84 \cos i - 1}$. This is called *Hutton's formula*, and the values are as follows: P^1 = pressure normal to the roof slope; P = horizontal pressure of the wind; i = the internal angle of the roof slope with the horizontal. Assume a roof slope of 30° and the usual horizontal wind pressure of 40 lb. per sq. ft. The formula $P^1 = P \sin i^{1.84 \cos i - 1}$ becomes, on substitution, $P^1 = 40 \sin 30^{1.84 \cos 30° - 1}$, and since $\sin 30° = .5000$ and the $\cos 30° = .8660$, by further substitution, the formula is $P^1 = 40 \times .5000^{1.84 \times .8660 - 1}$, or $P^1 = 40 \times .5000^{.59344}$. Referring to logarithmic tables, the calculation for this last expression is as follows: $\frac{1}{2}\text{Log } .5000 = \bar{1}.69897$, and $\bar{1}.69897 \times .59344 = -.17865$. Then

$$\log 40 = 1.60206$$
$$-.17865$$
$$1.42341$$

The number corresponding to this logarithm is 26.5, or P^1 the pressure in lb. per sq. ft. normal to the slope of the roof.

***

(200) What is the method of abstracting aluminum from soapstone and from clay?

T. B. Z., De Sota, Ill.

ANS.—Aluminum is obtained by an electrolytical process, the exact nature of which is kept a secret by the manufacturers.

***

(201) It has been stated that the top of a wheel moves faster than the bottom. If this is so, what is the explanation of it? H. H. S., Manchester, Conn.

ANS.—Suppose a vertical wheel to be revolving from left to right about a fixed horizontal axle O, Fig. 1, with the circumferential velocity v. Then the center O is at rest, and the highest and lowest points H and L have the same velocity v, but in opposite directions, as shown in the figure. Suppose, now, that while the wheel is thus rotating, the axle is moved horizontally toward the right, with the velocity v, as shown in Fig. 2. Then every point on the circumference of the wheel will be moving with two velocities, namely, a horizontal velocity toward the right equal to the velocity with which the wheel as a whole (that is, the axle) is moving, and a tangential velocity equal to the velocity of rotation of the wheel. Both of these velocities are equal to v, but the direction of the tangential velocity at any point depends on the position of the point, the direction of the latter velocity being the same as the direction of the tangent to the wheel at the point in question.

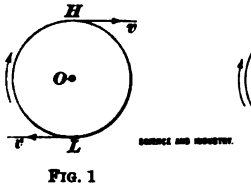


FIG. 1

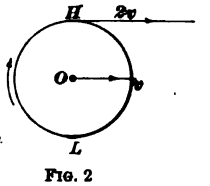


FIG. 2

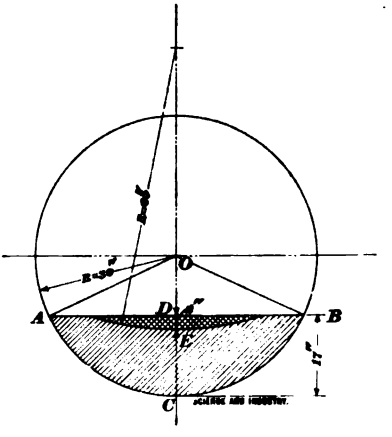
The tangential velocity of the highest point H is horizontal and equal to v, and this velocity, added to the velocity that H has in common with the whole wheel (since both velocities have the same direction), gives $2v$ as the velocity of the highest point. The lowest point has also a tangential velocity equal to v, but directed toward the left; so that the total velocity of L is the difference between the velocity it has in common with the whole wheel and its tangential velocity; that is, $v - v$, or zero. The lowest point of the wheel has, therefore, no velocity. The same conclusions apply to a wheel rolling on the ground, which is in the same condition as if its axle were being moved horizontally at the same time that the wheel revolved with the same velocity.

***

(202) Show how to determine independently the areas of the two shaded segments in the accompanying sketch. How is the central angle AOB found?

E. C., Wilmington, Del.

ANS.—We have $\cos AOC = \frac{OD}{OA} = \frac{OC - DC}{OA} = \frac{30 - 17}{30} = \frac{13}{30}$. Using trigonometrical tables, we get $AOC = 64° 19' 14.5''$. Hence, $AOB = 128° 38' 29''$.



The area of the sector AOB = (area of circle) $\times \frac{\text{angle } AOB}{360°} = OA^2 \times (1.1226079)$. Area of triangle $AOB = \frac{1}{2} OA^2 \sin AOB = OA^2 \times .3905345$. Subtracting the triangle AOB from the sector AOB, we get the area of the segment $ACB = OA^2(1.1226079 - .3905345) = OA^2 \times (.7320734) = 658.86606$ sq. in. In like manner, the area of the small segment is found to be 41.10872 sq. in.

***

(203) (*a*) Why does rifling increase the efficiency of a gun? (*b*) Are the 10-, 12-, and 13-inch guns of the navy rifled? (*c*) Give approximate weights and lengths of projectiles for the above guns.

H. M. H., Keller, W. Va.

ANS.—(*a*, *b*, and *c*) For full information on this subject address the general manager of the Hotchkiss Ordnance Co., 1503 Pennsylvania Ave., Washington, D. C.

***

(204) (*a*) What force per ton would it take to overcome the resistance of a 1.1% grade, there being a 24° curve on this grade, beginning at a point 264 ft. from foot of grade? (*b*) What power would be required to work this curve and grade at a speed of 10 miles per hour? (*c*) What is the tractive force of a locomotive having 18" × 24" cylinders, 140 lb. steam pressure, and 61" drivers?

A. M. B., Fort William, Ont.

ANS.—(*a*) The resistance per ton due to any grade is .38 N, where N is the number of feet per mile rise.

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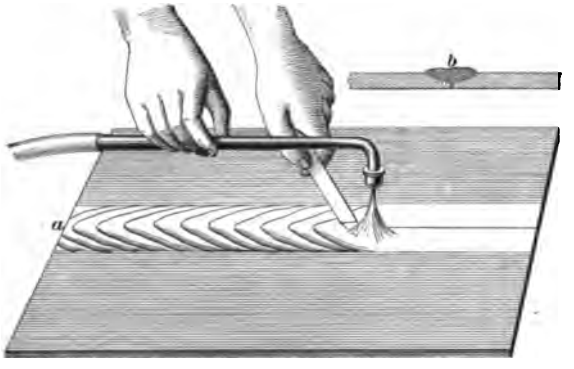
In your case $N = \frac{1.1}{100} \times 5{,}280 = 58.08$, and .38 of this is 22.07 lb. The resistance of the curve may be taken as .7 lb. per ton for every degree of curvature. Therefore, the resistance per ton is $2.5 \times .7 = 1.75$. The total resistance is therefore $22.07 + 1.75 = 23.82$ lb. per ton. The fact of the curve being some distance from the foot of grade does not affect the resistance. (*b*) Add 4½ lb. per ton to the above resistances. Knowing then that the resistance of your train is $23.82 + 4.5 = 28.32$ lb. per ton, and given the speed and weight of train, you can determine the horsepower required. (*c*) At 40 miles an hour, we may regard the mean effective pressure as being about 80 lb. The tractive force will be about 10,200 lb.

***

(205) Kindly explain a lead-burning machine and explain how it operates; also the process of lead burning. State what flux is used, if any.

J. C., Newport News, Va.

ANS.—A lead-burning machine of the generally accepted form is composed of a hydrogen-gas generator, an air tank, and an air pump. The generator is divided into two compartments, the upper one being open at the top and the lower one closed air-tight. They are joined together by a lead pipe extending nearly to the bottom of the lower chamber. The lower chamber is furnished with a perforated shelf about 2 in. from the actual bottom. Commercial zinc is laid on this shelf through a screw-cap opening shown on top. About 3 oz. of zinc will furnish 1 cu. ft. of gas. The charge of zinc should be about 20 to 25 lb. for a machine that is intended to run all day. A mixture of 5 parts of water to 1 part, by volume, of commercial sulphuric acid, is poured into the upper chamber. This flows into the lower chamber, where it rises until it acts on the zinc, when hydrogen gas is liberated and a pressure is formed in the lower chamber that forces the liquid back into the upper chamber. The column of liquid in the connecting lead pipe forms the desired pressure in the gas chamber. Gas is conveyed to a breeches pipe through a rubber tube, and air from the air holder that is loaded with weights to give the desired pressure is conveyed by another tube to the same breeches pipe. Two stopcocks on the breeches pipe are used to regulate the flow of air and gas into the mixing tube, which is generally held in the hand, so that the proportions of gas and air will be just right for a lead-burning flame. The process of burning is as follows: First, thoroughly clean the edges of the lead to be joined; adjust the blowpipe flame so that it will be about 1½ in. long, needle-pointed, and burning silently. Apply the flame so that the inner cone will touch the surface of the lead. The intense heat will melt the lead and cause the edges to flow together. The flux commonly used for this work is known as Yaeger's salts. Expert lead burners, however, operate without a flux when they use a hydrogen flame. The flux is generally used when an ordinary air and gas flame is employed. The illustration shows a good example for practice in lead burning. Two pieces of sheet lead are prepared by planing the edges to be joined straight and square, and shaving the top surfaces clean about ½ in. wide on each side of the butt joint; then the edges are butted together, and the sheets are firmly secured to a board. The flame is then applied, as shown, and it is fed from a lead stick held in the operator's left hand. This stick is about ¼ in. or more thick, triangular in section, and shaved clean. With the point of the inner flame a few drops of lead are melted off the stick and allowed to fall squarely on the seam. The flame should instantly follow these drops and fuse them to the sheet lead. A section through seam, when burned, is shown at *b*. It requires considerable practice to do this kind of work. Repeated failures may be expected at first.



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(206) Please tell me where I can obtain information relating to the use of petroleum, kerosene, gasoline, or illuminating gas in the generation of steam.

R. McK. A., Binghamton, N. Y.

ANS.—Considerable information regarding these fuels and their use in steam generation can be obtained from the following: "Heat and Heat Engines," by F. R. Hutton, price $5; "Kent's Mechanical Engineer's Pocketbook," price $5; and "The Calorific Power of Fuels," by Herman Poole, price $3. Any of these books may be obtained from The Technical Supply Co., Scranton, Pa. The following concerns manufacture apparatus for burning oil: W. S. Rockwell & Co., Havemeyer Building, New York; W. J. Browne, 623 Drexel Building, Philadelphia, Pa.

***

(207) (*a*) How much and what size of wire must be put on the fields of a shunt-wound dynamo that has as a series machine, 3 lb. of No. 18 D. C. C. on the fields and 1 lb. No. 22 D. C. C. on the armature? The machine is to give a current of 4½ amperes at a pressure of 20 volts. Please give size in B. W. G. (*b*) Please tell me how to make an electric fuse to explode gunpowder. Current to be used is 2½ amperes, pressure 4 volts.

L. S., Dorchester, Mass.

ANS.—(*a*) The weight of wire on the field should be about the same for either the shunt or series winding, though with the shunt winding the insulation will take up a greater amount of space, and the weight that could be put in the available space would probably not be more than 2½ lb. If you use No. 24 B. W. G., this will give a field resistance of about 40 ohms and a shunt current of ½ ampere, which is about as low as can be expected in a machine of this size. You may have some trouble making such a small shunt machine run properly and excite its own field magnets. (*b*) You can make a simple fuse, as shown in the figure. Take a small piece of hard wood *a* and drill two holes through it so as to hold the insulated lead wires snugly. Across the ends of the wires attach a small piece of platinum wire *b*, about No. 28 or 30 B. & S. This wire may be fastened to

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the lead wires by twisting the two together, but a better way is to fuse the copper around the platinum by means of a blowpipe.

***

(208) (*a*) Please show me a way in which I can make a miter box for picture framing. (*b*) What is the best filter for a residence? The filter box is in the ground under the spout, and about 6 ft. from the top of the cistern. N. H. T., Lima, Ohio.

ANS.—(*a*) The miter box for ordinary work should be made of hard wood, about 18 in. long, 4 in. wide,

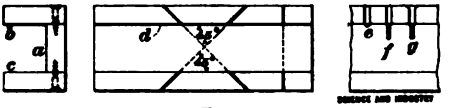

FIG. 1

and 1½ in. thick. The bottom piece *a* in Fig. 1 must be planed perfectly flat and have parallel and square edges. The sides *b* and *c* are firmly secured to the bottom piece with screws. The holes for these screws should be bored as shown at *e*, *f*, *g*, Fig 1. The saw cuts are laid out from the faced edge *d*, and are made with the saw that is to be used in the box. (*b*) Fig. 2 shows one of the best forms of filters used for filtering rain water as it flows into an underground cistern. The body of the filter is of brick, laid in Portland cement, mixed with an equal volume of clean, sharp sand, and it is divided into two chambers by means of a partition *a* of slate or flagstone. The bottom of chamber *A* is provided with a pocket *d* in which sediment may gather and from which it may easily be removed by a common garden pump. The chamber *B* is fitted with a perforated bottom *b*, on which is placed gravel and clean sand of different grades. Rain water enters chamber *A* through pipe *c* and deposits any solids that may accompany it at *d*. The water then flows upwards through the sand beds, where it parts with impurities. Then it flows through *f* as filtered water into the cistern. An overflow pipe *e* should discharge above the ground at some convenient point. This filter, it will be seen, is quite accessible in all its parts when the cover is removed. This is an important point, when we consider that filters should be thoroughly cleaned periodically.

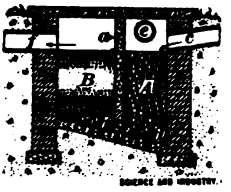

FIG. 2

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(209) Please illustrate the use of anti-logarithms. S. R. K., New York.

ANS.—The word *anti-logarithm* is used in two senses: (1) If *a* is the logarithm of *b*, then *b* is called the anti-logarithm of *a*. The following notation is used: $a = \log b$, $b = \log^{-1} a$. If you are familiar with logarithms, you know the use made of anti-logarithms in this sense of the term. Otherwise, our explanation would be unintelligible to you. (2) The term *anti-logarithm* is also used (although rarely) in the sense of *arithmetical complement*, or *co-logarithm* (written "co-log"); which means the logarithm of the reciprocal of a number. Thus, $\text{co-log } a = \log \frac{1}{a} = -\log a$. Co-logarithms (this is the usual name) are used in performing divisions by logarithms, on the principle that *instead of subtracting the logarithm of a number we may add its co-logarithm*. The latter is obtained by adding 1 to the characteristic of the logarithm and changing its sign, and subtracting every figure in the mantissa from 9, except the last, which is subtracted from 10. Suppose that we wish to find the value of $\frac{a\,b\,c}{m\,n\,p}$, and that the table gives $\log a = 1.84763$, $\log b = \bar{1}.84738$, $\log c = .80091$, $\log m = 2.78967$, $\log n = \bar{2}.99887$, $\log p = 3.11678$. Instead of adding the last three logarithms and subtracting the result from the sum of the first three, we may use co-logarithms and dispose the operations thus:

$$\begin{aligned}
\log a &= 1.84763 \\
\log b &= 1.84738 \\
\log c &= .80091 \\
\text{co-log } m &= 8.21033 \\
\text{co-log } n &= 1.00113 \\
\text{co-log } p &= 4.88327 \\
\log \frac{a\,b\,c}{m\,n\,p} &= 4.59065
\end{aligned}$$

The corresponding number (which is more properly called the anti-logarithm) can be found by the use of a table.

***

(210) In the February, 1900, issue of SCIENCE AND INDUSTRY, H. D. S. asks for a paint for gauges that will show white in the dark. If he will write to Martinka & Co., 493 Sixth Ave., New York City, he can obtain a paint that will give a phosphorescent glow at night. By painting the face of the gauge white, and the figures and hands black, the gauge readings may be taken very well at short distances. Will you kindly inform me as to where I can procure a copy of the underwriters' rules for electric wiring, and how much it will cost? A. G. K., Omaha, Neb.

ANS.—Write to the National Board of Fire Underwriters, 157 La Salle St., Chicago, Ill. We believe these rules are usually furnished gratis.

***

(211) Will you kindly show how the depth of an elevator air cushion can be calculated so that it will arrest a falling car without injury to life? The car I have in mind weighs, inclusive of the load, 4,000 lb. The platform is 5 ft. × 5 ft. The drop of the car is 100 ft. J. A. B., Philadelphia, Pa.

ANS.—We quote the following from a letter of advice kindly furnished us by an authority on elevators, to whom we submitted your question: "The depth of the air cushion is usually made ¼ of the drop, or 20 ft. in a 100′ drop. This proportion, as will follow from calculation, brings about 5 times the weight of the upper part of the human body on the spinal column and 5 times the weight of the body on the ankles, or, say, 200 lb. on the column and 300 lb. on each of the ankle joints. This can be sustained without injury." Your elevator, having a travel of 100 ft., would then require a depth *d* of air cushion equal to $d = \frac{1}{4}(100 + d)$, from which $d = 25$ ft. "The vent at the top of the air cushion or the clearance around the bottom of the car must be calculated to be of such size as to make the pressure of efflux the same as is needed to stop the car falling from a height of 100 ft. in 20 ft." Your car weighing 4,000 lb. would have acquired at the end of the fall, without cushion, an energy equal to 4,000 × 125 = 500,000 ft.-lb. This must be taken up in the depth of the air cushion of 25 ft. Thus the work of the resisting air pressure *P* underneath the car bottom must be equal to 500,000 ft.-lb., or $P \times 25 = 500{,}000$, from which $P = 20{,}000$ lb., or with a platform of 5 ft. × 5 ft., 5.56 lb. per sq. in. After a drop of 100 ft., the car with load will strike the top of the air cushion with a speed of 82 ft. per sec., or 4,920 ft. per min. "This speed is so great that scarcely any air escapes during the first few feet of the depth of the air cushion until the pressure (5.56 lb.) for which the clearance is calculated is reached. To figure the vent or clearance at the top of the cushion, the problem is:

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What must be the size of an opening or port to let the air escape under a pressure of 5.56 lb., if a piston of 5′ × 5′ area compresses with a speed of 82 ft. per sec.?" The quantity of air issuing through the vent per second is in your case 5 × 5 × 82 = 2,050 cu. ft. According to Peabody's formula, the quantity of air (in pounds) issuing from a reservoir per second through an orifice of an area F square inches is $G = 1.06\,F\sqrt{\frac{p_a\,(p_1 - p_a)}{T}}$, when $p_1 < 2\,p_a$, in which p_1 is the absolute pressure in the reservoir; that is, 14.72 + 5.51 = 20.23 lb. per sq. in. in the present case; p_a the absolute pressure on the outside, that is, 14.72 lb. per sq. in.; and T the absolute temperature, which, if we take the average temperature in elevator shafts to be 60° F., is 460 + 60 = 520. Thus we have, since the weight of a cubic foot of air is .08 lb., $G = 2{,}050 \times .08 = 1.06\,F\sqrt{\frac{14.72\,(20.28 - 14.72)}{520}}$ = 1.06 × .39 F. F = 397 sq. in., or 400 sq. in., nearly. Your sketch gives the area of the vent as 496 sq. in., which, considering that the outflow of air will not commence before the car has descended several feet into the cushion, seems about right. Our authority further states: "From this clearance at the top between the car and sides of cushion the sides taper down to a close fit at the bottom of the cushion. If so built, the car will stop without jar or shock, and without rebounding." The practical efficiency of air cushions has been repeatedly demonstrated by tests.

***

(212) What is the meaning of C^2R losses when used in regard to the loss of energy in traction motors? E. H. O., Philadelphia, Pa.

ANS.—When a current of electricity is sent through a wire there is always a certain amount of loss due to the resistance that the current encounters in passing through the wire. This same loss occurs in the field and armature windings of a motor, and it always reappears in the form of heat. If R is the resistance of a wire in ohms, and C the current in amperes, then the loss is C^2R watts; hence, this loss is frequently called the C^2R loss, to distinguish it from the losses in the armature core, friction, etc. For example, suppose the armature of a motor has a resistance of .5 ohm, and that the current flowing through it is 20 amperes; then, the watts lost in heating the conductors will be $C^2R = 20 \times 20 \times .5 = 200$.

***

(213) (*a*) Is there a double-beat safety valve in use? (*b*) If so, please explain its construction, and give an outline of its advantages and disadvantages. A. R., Glasgow, Scotland.

ANS.—(*a*) We have never known of the use of a double-beat valve for a safety valve. (*b*) The only advantage we can think of would be that a comparatively small pressure would be required to hold the valve to its seat. A very serious disadvantage would be the difficulty in preventing leakage.

***

(214) I am employed in a newspaper office and run a press and folding machine. Sometimes we have a great deal of trouble with the electricity in the paper; frequently it is so charged that it is impossible to feed it into the folding machine. Can you tell me the cause of this electricity, and how to take it out? O. K., Stockton, Cal.

ANS.—The electricity is probably caused by friction on the paper, or by electrostatic induction. If you lay a few sheets of calendered paper on top of each other and rub the top sheet briskly with the hand, the next sheet will be pulled up with the top sheet when an attempt is made to lift it. There has been a great deal of experimenting done to discover some means of overcoming the trouble you speak of, but we do not know of any method that has proved generally successful. It will do no harm to see that the press is well connected to the ground by running a copper wire from the frame to a water pipe, but this will not likely cure the trouble. Perhaps some of our readers may be able to suggest a remedy.

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(215) Please solve the following problems: (*a*) What is the length of the longest rectangular plank 3 ft. wide that can be laid upon the floor of a room

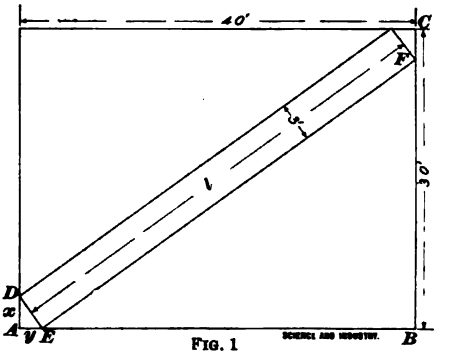

FIG. 1

40 ft. long by 30 ft. wide? (*b*) I wish to survey a race track, as shown in Fig. 2, so that each of the tangents $b\,p$ and $a\,p$ and the arc $a\,c\,b$ shall be 1,760 ft. long; what is the radius $o\,b$ of the circle? D. K., Holdrege, Neb.

ANS.—From the similar triangles $E\,A\,D$ and $F\,B\,E$, we have

$$\frac{y}{x} = \frac{30 - x}{40 - y}. \qquad (1)$$

From the right triangle $E\,A\,D$, we have

$$x^2 + y^2 = 9. \qquad (2)$$

Eliminating x between (1) and (2), we get

$$4y^4 - 160y^3 + 2{,}464y^2 + 720y - 8{,}019 = 0. \qquad (3)$$

Solving (3) by Horner's method, we get $y = 1.7542$. Hence, from (2), we get $x = 2.4837$. Again, from the similar triangles $E\,A\,D$ and $F\,B\,E$, we have

$$\frac{l}{40 - y} = \frac{3}{x}. \qquad (4)$$

Substituting the known values of x and y in (4), we get $l = 47.145$. (*b*) Let y be the circular measure of the angle A; then, $b\,p$ = arc $a\,c\,b$ = (circumference − arc $a\,x\,b$) = $2\,o\,b(\pi - y)$. And $\tan y = \frac{b\,p}{o\,b}$ = $\frac{2\,o\,b(\pi - y)}{o\,b} = 2(\pi - y)$. The equation $\tan y = 2(\pi - y)$ determines the angle y, or A; this equation can only be solved by trial. As the angle y increases from 0 to $\frac{\pi}{2}$, $\tan y$ increases from 0 to infinity; and $2(\pi - y)$ decreases from 2π to π, or from 6.28318 to 3.14159. Hence, $\tan y$ must lie between 6.28318 and 3.14159. From a table of natural tangents, $\tan 74° 46′ = 3.67217$; from a table of circular measures of angles, circular measure of 2 (180° − 74° 46′) = circular measure of 2(105° 14′) = 3.67384. Since $\tan 74° 46′$ is less than the circular measure of 2(180° − 74° 46′), this angle is too small. A second trial gives $\tan 74° 46′ 15″ = 3.67322$, and circular measure of 2(180° − 74° 46′ 15″) =

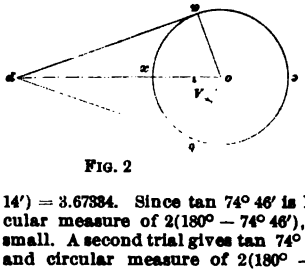

FIG. 2

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3.67320. Therefore, $A = 74° 46' 15''$. But $ob = bp \cot A = 1{,}760' \cot 74° 46' 15''$; hence, $ob = 479.1452$ feet.

***

(216) (*a*) Does sound travel faster on water than on land, under the same conditions? If so, how much faster, and why? (*b*) Can messages be sent through solid stone, steel, and brick walls by Marconi's telegraph system? If so, why?

W. W. B., Cleveland, Ohio.

ANS.—(*a*) Sound travels through the air over the land and sea at the same speed under exactly the same atmospheric conditions. However, it will travel farther on sea because there are no hills, mountains, houses, trees, etc. to interrupt the air waves. (*b*) Yes; messages, in one experiment recently made in Philadelphia, were transmitted through five heavy stone walls, an iron staircase, and three door casings. We know that for heat rays, rock salt is transparent and glass is opaque; for light rays, glass is transparent and a brick wall opaque; for Roentgen rays, a brick wall forms no obstacle. So ordinary objects are transparent to Hertzian waves, but a solid box of metal apparently shields the coherer from such Hertzian rays as Marconi uses; but it also seems probable that the box does not act as a good shield to longer Hertzian waves. No good explanation has been given of this, but Marconi himself says that the Hertzian waves sent out by his transmitters very easily go around or over obstacles, implying that they do not go through. These waves are very long (probably 200 ft.), and the facility with which they go over obstacles may be likened to the ease with which Gulliver could step over the walls and houses of the Lilliputians. There are physical phenomena with the laws and results of which we are perfectly familiar and have been for ages, but no definite explanation of them can be given, although theories more or less true are offered.

***

(217) If a house can be warmed to a temperature of 60°, when the outside temperature is 20° below zero, with a hot-water heating apparatus, the water being maintained at a temperature of 180°, to how many degrees will the same house be warmed when the outside temperature is 70°, the water being kept at a temperature of 180°, all other conditions being the same in both cases? J. C., Kingston, Ont.

ANS.—The temperature in a building in such a case will be somewhat variable, according to existing conditions, but should range somewhere between 110° and 111° F.

***

(218) I have made a gasoline engine of the two-cycle type, with a cylinder 6 in. long and 2¼ in. diameter. The length of stroke is 2¾ in. The exhaust port is 1⅛ in. × ⅜ in., and the admission port is ⅛ in. The crank-end of the cylinder is closed with a stuffingbox. That end draws the charge from the carbureter and forces it into the compression chamber. The charge is compressed to one-third of its initial volume and ignited by an electric spark just before the piston reaches the head-end of the cylinder. Just before the piston reaches the crank-end of its stroke, the exhaust port opens and the charging port at the compression end of the cylinder opens and admits a fresh charge. The engine will run for 8 or 10 revolutions, then it will gradually slow down and finally stop. I have tried several flywheels. One 12 in. in diameter, weighing 34 lb.; one 8 in. in diameter, weighing 14 lb.; and one 10 in. in diameter, weighing 24 lb. Tell me where the fault in my engine lies. J. C. E., Reading, Pa.

ANS.—Your description of the engine does not make clear how the different parts are constructed and what their relative positions are; it is therefore difficult to decide where the fault lies. Some of the possible causes of the failure of the engine to work are: The carbureter may not furnish enough gas; the engine cylinder may not be properly cooled, and the heat of the explosions may cause the piston to bind and run hard; the heat may act on the valves and so prevent them from opening or closing properly; the arrangement of the valves may be such that the exhaust is not properly expelled, thus preventing the admission of enough gas from the compression chamber to secure an explosive charge that will keep the engine in motion; the valves may not open or close at the right points in the stroke; the sparking device may be so affected by the heat as to prevent it from acting properly after the engine is started.

***

(219) Please explain how to find the center of gravity of a disk with a circular hole in it, the data being as follows: Diameter of disk = *D*, diameter of hole = *d*, distance from center of hole to center of disk = *a*. G. I. B., Freeport, L. I.

ANS.—The center of gravity lies in the line, *produced*, joining the center of the hole and the center of the disk, at a distance from the latter center equal to $\frac{a\,d^2}{D^2 - d^2}$.

***

(220) I find that my smoothing plane, jack-plane, and other wooden planes become very dry and crack. Please tell me what to use to prevent this.

A. L., St. Louis, Mo.

ANS.—The only way in which you can prevent the trouble is to thoroughly saturate the block of the plane with raw linseed oil. Planes should be soaked in it until they cease to absorb the oil.

***

(221) (*a*) Has electricity any weight, and if so, how is it obtained? (*b*) If several batteries were charged, would they weigh more than before being charged? I. W. B., Bristol, Conn.

ANS.—(*a*) Electricity does not possess weight. Electricity should not be looked upon as possessing weight any more than light or heat. (*b*) No; a storage battery would probably weigh slightly less after being charged, because there is always a certain amount of gas given off. The energy is stored up by the chemical changes that are made to take place under the action of the current, and not by the addition of anything to the battery that would cause an increase in weight.

***

(222) (*a*) Can a hollow iron ball be cast, and will it be as strong as a solid one? (*b*) Give me full instructions for making a telescope for a rifle, so that a good mechanic could make it if he were furnished the lenses and tube. (*c*) How can I ebonize wood, that is, stain it a fast black? (*d*) How is fine checkering done on wood? State what tools are needed for the work. C. M., Brooklyn, N. Y.

ANS.—(*a*) Hollow balls can be cast, but they must have two holes due to the core prints supporting the core in the molds. Through these holes the core can be removed after casting. They are then plugged up. A hollow ball of the same weight as a solid one is not as strong. (*b*) To answer this question would require too much space, and would not be of general interest. Besides, a telescope made especially for that purpose and purchased from a reliable dealer will be much more satisfactory and probably cost you less in the end. (*c*) Wood may be ebonized by painting it with the combined solutions of copperas and logwood. Boil a pound of logwood in a gallon of water, allow it to settle, and strain through muslin. Then make a saturated solution of copperas in water, or dissolve some rusty nails in vinegar. Paint the wood thoroughly with either of the two latter solutions, and, when dry, apply the logwood solution over it. A second painting of copperas, followed by a second painting of logwood, will dye the wood an unalterable black that may be polished with oil and

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varnished. The best wood for this purpose is cherry. (*d*) Checkering on wood is usually done by inlay, although a fair imitation of it may be secured by ebonizing the checkers as above, under which circumstances it will be necessary to saw a slot on the lines dividing the checkers and insert a piece of rubber or other waterproof material, in order that the dye may not extend from one checker to the next one. The only tools required in either case are the ordinary carpenter's tools—back saw, plane, and chisel.

***

(223) I wish to construct a hand-power dynamo without the use of cast iron for the field magnet. I wish to use in its place a field built up of layers of sheet iron or a solid piece of wrought iron. (*a*) Will this work in a machine otherwise built as if a cast-iron field were to be used? If not, how can the field be made without castings? (*b*) How many watts are equal to 1 manpower? (*c*) Will all motors act as dynamos? P. D., Lebanon, Kan.

ANS.—(*a*) A laminated or wrought-iron field should work fully as well, if not better, than a cast-iron field, because the magnetic qualities of the wrought or sheet iron are better than those of cast iron. (*b*) A man working continuously 8 hours a day can work at the rate of about $\frac{1}{10}$ horsepower, or about 75 watts. (*c*) No; some small motors will not operate as dynamos because they are not capable of exciting their own fields.

***

(224) (*a*) What chemicals are used in making black-process paper for printing from tracings, so that the lines will appear black on a white background? (*b*) How are they mixed and spread on the paper? O. L. H., Stockton, Cal.

ANS.—(*a* and *b*) An article describing this process was published in the November, 1898, issue of "Home Study Magazine."

***

(225) (*a*) Give me the proper directions for making carbon cylinders and plates, with instructions for baking them, etc. (*b*) Of what is dense carbon made? W. W. L., Philadelphia, Pa.

ANS.—(*a*) It is impossible to give a description of the process of carbon making in these columns, as space does not permit of an explanation full enough to be of any practical use. The process of making carbons is a complicated one, and we would advise you to get a book on the subject, if you are contemplating work of this kind. A work on this subject has recently appeared. It is entitled "The Manufacture of Carbons for Electric Light and Other Purposes," by Francis Jehl. (*b*) The material used for making carbons in America is what is known as "petroleum coke," i. e., the carbon made from the residue from petroleum after all the volatile products have been driven off in the process of refining. Gas-retort carbon has also been used to some extent. The book referred to above may be obtained from The Technical Supply Co., Scranton, Pa.

***

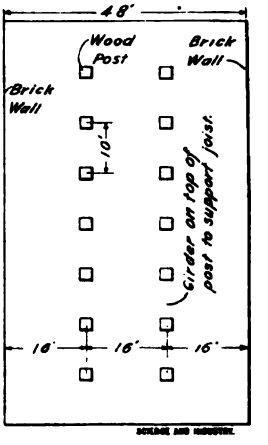
(226) What will prevent the kicking of the hot-water connections between a kitchen stove and a hot-water boiler? There is a pitch of at least ½ in. per ft. to all pipe. The hot-water pipe from the stove is connected to the middle of the boiler. The tank above is about 4 ft. higher than the top of the boiler. The noise troubles us a great deal in cold weather, when we want to keep the kitchen warm, and also when we get the oven hot enough to bake.
C. B., Worcester, Mass.

ANS.—We believe the noise proceeds from mud or other material choking the lower pipe that connects the boiler to the range, or from too small a pitch on the upper pipe that connects the range to the boiler. If it worked successfully for a long time after the job was first put in, you will probably find that the lower pipe is clogged with mud, or perhaps the upper pipe has a lime incrustation; but if you have experienced trouble right along from the time the work was installed, we think you will be required to change the upper connection from the side of the boiler and make it enter at the top. This will increase rapidity of circulation through the water-back, and prevent the formation of steam, which is really the cause of your trouble.

***

(227) What would be the size of the joists, wooden girders, and timber columns in the warehouse built as per enclosed sketch?
H. H. F., Grand Island, Neb.

ANS.—You do not give the floor load, so the best that we can do is to give you the formulas so that you can figure the sizes for yourself. The safe uniformly distributed load that any rectangular joist or girder will sustain can be determined by the formula $W = \frac{4bd^2S}{3l}$, where b = breadth or width of beam, d = depth of beam, l = span of beam, all in inches, S = safe unit fiber strength of the material, and can be obtained from the table given herewith.



Character of Timber.	Value of *S*.	Value of *U*.
White pine	1,000	875
Georgia yellow pine	1,750	1,250
Hemlock	875	1,000
Spruce	1,000	1,000

The load that a wooden column will safely sustain can be calculated by the formula $W = A\left(U - \frac{U \times l}{100\,d}\right)$, where A = sectional area of column in sq. in., U = safe unit compressive strength of material, l = length, and d = least dimension of column, in inches. The value of U can be obtained from the same table as S. Both the values S and U, as given, allow a factor of safety of 4, using commercial timber.

***

(228) Please give me directions for making an X-ray outfit, the simpler the better. If you cannot tell me how to make the outfit, please tell me where I can obtain the information necessary.
W. C. S., Woodruff, Utah.

ANS.—For an X-ray outfit you should have a 5- or 6-in. tube, a 6-in. spark induction coil with the necessary batteries for running it, and a fluoroscope. It would hardly be possible for you to make the tube, but you could make the rest of the apparatus required. Space does not permit us to give instructions for making the coil, but you can obtain the necessary directions in any book on coil making, such as "Induction Coils," by Bonney. Ordinary oxide of zinc is said to work very well for the fluoroscope. In order to make the screen, take a piece of heavy pressboard about 8 in. × 10 in., cover

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it with a thin layer of paraffin, and dust on the zinc oxide evenly; then warm slightly so as to melt the paraffin, and the oxide will be held firmly in place. The screen should be mounted in one end of a conical-shaped box, with an opening at the other end through which to observe the image. The book on induction coils referred to may be obtained from The Technical Supply Co., Scranton, Pa.

***

(229) (*a*) How many amperes will it take to light ten 10 c. p. incandescent lights at 50 volts, if 3½-watt lamps are used? (*b*) I have a small shunt-wound dynamo giving 50 volts; if I should open the main switch suddenly with the full load on, would it injure the dynamo in any way? (*c*) Would a 6-ampere fuse 2 in. long carry the same current as one 4 in. long? (*d*) What would be the dimensions of an electromagnet to support a weight of 50 lb., when the current is furnished by 4 or 5 cells of battery? (*e*) What would be the size and weight of wire on such a magnet? E. P. B., Santa Barbara, Cal.

ANS.—(*a*) Each lamp will require 35 watts for its operation; hence, the 10 lamps will require 350 watts. Since the voltage is 50, the current required will be $\frac{350}{50} = 7$ amperes. (*b*) In the case of a dynamo generating a pressure as low as 50 volts, there should be no danger in throwing the load off suddenly. If the machine were of high voltage, it would not be safe to break the field current suddenly, because the high E. M. F. induced might puncture the field insulation. (*c*) The short fuse would probably carry a larger current than the long one, on account of the cooling effect of clamps at the end of the fuse. If the fuses are very short, the heavy clamps at the end radiate the heat and keep the fuse from melting. If short fuses must be used, they should be proportioned so as to allow for this cooling effect. (*d*) This question is very indefinite, as you say nothing about the type of cell you intend using. A magnet made as follows should support about 50 lb., if your battery is capable of supplying it with ¾ ampere: Make the core of ⅜" round wrought iron of good quality, bent into horseshoe form, making the legs 4 in. long from the poles to the center of the bend, and the spread about 3 in. from center to center of poles. Chamfer the poles so that the pole faces will be ½ in. in diameter, in order to secure a high magnetic density at the polar surfaces. Wind on each leg 360 turns of No. 18 B. & S. double cotton-covered magnet wire. (*e*) The weight of wire required will be in the neighborhood of 1½ lb.

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(230) Please inform me where I can procure a book treating on screw cutting, and lathe work in general. L. F. U., North Amherst, Ohio.

ANS.—"Modern Machine Shop Practice," by Rose, price $18.00; "Lathe Work," by Hasluck, price $2.00; "Turning Lathes," by Lukin, price $1.00. These books may be ordered through this magazine, or from The Technical Supply Co., Scranton, Pa.

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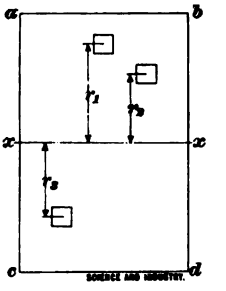
(231) (*a*) Please tell me how to find the voltage and current in each phase of a star- or a delta-connected motor in any of the standard voltages; also state which is the better connection. (*b*) How much larger would an aluminum wire have to be to transmit power with the same loss as a copper wire; in other words, what would be the ratio in circular mils? (*c*) What is *moment of inertia*, and how is it determined? J. B., Central Falls, R. I.

ANS.—(*a*) If a motor takes a certain number of watts at full load from a three-phase line at a given voltage, the current per line will be the same, no matter whether the star connection or delta connection is used. The style of connection of the motor winding determines the current in, and the voltage taken up in, each phase of the winding. If W represents the total watts input, E the voltage between the lines, and C the current in each line, then we must have the relation $W = C \times E \times \sqrt{3} = C \times E \times 1.732$, and $C = \frac{W}{E \times 1.732}$. For example, suppose a three-phase motor took 10,000 watts at full load and that the pressure between the lines was 220 volts. Then the current per line would be $C = \frac{10{,}000}{220 \times 1.732} = 26.2$ amperes, nearly. One type of winding has no particular advantage over the other, as far as the operation of the motor is concerned. Generally speaking, the Y connection is better adapted for a high E. M. F., and the △ connection for a large current. (*b*) The conductivity of aluminum is about 60% that of copper, so that the area of cross-section of the aluminum wire must be 1.66 times that of the corresponding copper wire to transmit the same amount of power with the same loss. The circular mils of the aluminum wire can, therefore be obtained by multiplying the circular mils of the copper wire by 1.66. (*c*) Suppose we have an area *a b d c* which may represent, for example, the cross-section of a beam. Let *x x* be any axis of reference. Suppose this area to be divided into a number of very small areas, as represented by the small squares, and let r_1, r_2, r_3 be the distances of these small areas from the axis *x x*. If each small area is multiplied by the square of its distance r from the axis and these results added together, the sum will be the moment of inertia of *a b d c* with reference to the axis *x x*. The methods of calculating the moment of inertia would occupy more space than we can allow in these columns. In the majority of cases, the ready calculation of moment of inertia involves the use of the calculus. You will find the methods of calculation described in almost any good work on mechanics of engineering.



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(232) I wish to cut a manhole, 11 in. × 15 in., crosswise in a boiler plate ⅜ in. thick, tensile strength 55,000 lb. Please give formula for reenforcement ring, and also number and pitch of rivets for fastening the same. E. M. A., Akron, Ohio.

ANS.—The reenforcement ring should have a cross-section equal to the portion cut out of the lengthwise section of the plate. Thus, if w = width of ring, t = thickness of the same, d = diameter of rivets, we have: $11 \times \frac{3}{8} = 2 \times w \times t - 2 d \times t$, assuming that two rivet holes will fall in the ring section considered. For iron plates and rivets, the diameter of rivets should be $d = t' + \frac{1}{8}$, in which t' = thickness of boiler plate; thus, $d = \frac{3}{4}$ in.; this, inserted in the first equation, gives $4\frac{1}{8} = 2wt - \frac{3}{4}t$. The width w will depend, assuming two rows of rivets, which is preferable, on the distance between the two rows and the distance of rivets from the edge of the ring. The distance aforesaid again depends on the pitch. As the rivets do not here serve the same purpose as in the boiler seams, we may use the maximum allowable pitch. The rules of the British Board of Trade give the maximum pitch for double-riveted lap joints as $p = 2.62t' + 1\frac{3}{4}$ in.; thus, in your case, $p = 2.61$ in., or $2\frac{5}{8}$ in., nearly. The same rules give for the distance between the two rows of rivets, $b = \frac{\sqrt{(11p + 4d)(p + 4d)}}{10}$, which gives $b = 1.333$, or $1\frac{11}{16}$ in., nearly. The distance of rivets from edge

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should be $\frac{1}{2}d = 1\frac{1}{4}$ in. The width of the plate thus becomes $w = 1\frac{1}{16} + 2 \times 1\frac{1}{4} = 3\frac{13}{16}$, say 4 in. Inserting this in the first equation, we get $\frac{3}{4}^3 = 2 \times 4 \times t - \frac{1}{2} \times t = 6\frac{1}{2}t$, from which $t = \frac{27}{64} \times \frac{1}{13} = \frac{27}{832} = .63$ in., or $\frac{5}{8}$ in., nearly. Laying the ring out you will find that you need 36 rivets. The ring may be riveted to the inside or the outside of the shell. It is often, when placed on the inside, flanged and faced, making the cover flat and providing a metallic joint. The riveted part cannot, in this case, be made much narrower than 4 in., and the flange thus providing additional cross-section, the thickness can be reduced, say, to $\frac{1}{2}$ in.

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(233) If a metallic-circuit telephone line has the same amount of induction on each wire, will there be any humming or disturbance from induction?

H. B. Y., Norway, Me.

ANS.—Provided there is no accidental or intentional ground anywhere on the circuit, there will be no disturbance.

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(234) In the figure, $a\,b$ and $b\,c$ are known; $m\,n$ $(= m'\,n')$ is also known. Required, the extreme distances $c\,n$, $c\,m$, $c\,n'$, and $c\,m'$. O. F. N., Beloit, Wis.

ANS.—Let $m\,n = l$, $a\,d\,(= b\,c) = h$, $a\,b\,(= d\,c) = k$, $c\,m = x$, $c\,n = y$. The right-angled triangle $m\,c\,n$ gives

$$x^2 + y^2 = l^2. \qquad (1)$$

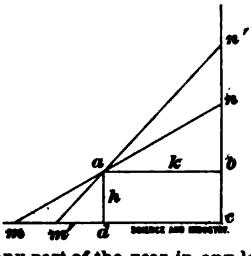
The similar triangles, $m\,d\,a$ and $m\,c\,n$ give

$$\frac{m\,d}{d\,a} = \frac{m\,c}{c\,n}, \text{ or } \frac{x-k}{h} = \frac{x}{y}.$$

Whence,

$$x\,y - h\,x - k\,y = 0. \qquad (2)$$

By eliminating y between (1) and (2), we get $x^4 - 2k\,x^3 - (l^2 - h^2 - k^2)\,x^2 + 2k\,l^2\,x - k^2\,l^2 = 0$. This equation has two real roots, which may be found by known methods: one of them gives $c\,n$; the other $c\,n'$. The values of y may be found from (2), after x is known; one value gives $c\,m$, the other, $c\,m'$.



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(235) Please explain how, or give a formula for finding the time when the sun will rise or set for any part of the year in any longitude and latitude. How is this affected by altitude, say 8,000 ft. and 14,000 ft.? E. A. R., Chicago, Ill.

ANS.—To find the time of rising or setting of a celestial object, whether it be the sun, moon, or a star, the following formula may be employed: cos H. A. = tan Decl. × tan Lat., where H. A. = hour angle; Decl. = declination; Lat. = latitude of observer. This formula gives the hour angle of the object when rising or setting, and thence the time. In computing the latitude, due allowance must be given for the dip of the horizon (depending on the *height* of the observer), refraction, semidiameter, and parallax (if sun or moon).

***

(236) (*a*) Please tell me what kind of an apparatus I will need and the method used to determine the specific heat of a liquid. (*b*) Is there any book that gives the specific heats of every known liquid? (*c*) How can I tell from an indicator diagram when my engine is cutting off at the point that will give the highest efficiency? (*d*) If an automatic cut-off engine is doing variable work with a cut-off varying from 0 to $\frac{3}{4}$ stroke, would it not improve the economy to use a throttling governor on the steam pipe, so adjusted as to make the engine cut off at, say, $\frac{1}{4}$ stroke with friction load? (*e*) I propose to construct a pond 100 ft. square and 2 ft. deep, to be used to obtain ice. The soil upon which the pond would be made is sand, and water stands 10 ft. below surface. A sewer runs past, 50 ft. away. I would use city water to fill the pond, and would like to know if I would lose a serious amount of water by soaking away. If so, can you tell me how to make a cheap and durable bottom for same? (*f*) How much fresh water would be required to be added daily to a pond 100 ft. square and 2 ft. deep, containing 125,000 gal. of water, to prevent its becoming stale in winter weather? A. N., Toronto, Can.

ANS.—(*a*) Specific heats of substances are determined by a variety of different methods, of which the simplest and most easily applicable to the case of liquids is probably the "method of mixtures." By this method, a known quantity of the substance is heated and its temperature measured. It is then immersed in, or mixed with, a liquid whose weight, temperature, and specific heat are known. The temperature of the mixture is then measured. A little consideration shows that, if there is no loss from radiation or other source, the heat given up by the substance whose specific heat is required, in cooling from its original temperature to the temperature of the mixture, is equal to the heat absorbed by the liquid with which it is mixed. Letting W, t, and c represent, respectively, the weight, temperature, and specific heat of the liquid whose specific heat is known; W', t', and c', the corresponding quantities of the substance whose specific heat is required; and t_1', the temperature of the mixture, we have $W \times (t_1' - t) \times c = W' \times (t' - t_1') \times c'$. From this equation, we have

$$c' = \frac{W \times (t_1' - t) \times c}{W' \times (t' - t_1')}.$$

The apparatus required for the application of this method consists of accurate scales and thermometers and a suitable vessel in which to mix the two substances. The process is extremely simple in theory, but in practice there are many disturbing influences that make it difficult to secure exact results. Heat is absorbed by, and radiated from, the vessel in which the mixture is made, and allowance must be made for this and similar losses whose exact values it is difficult to measure. The different methods used in determining specific heats, together with the apparatus employed by leading experimenters, are described and illustrated in all standard works on physics. One of the most complete descriptions is that contained in Ganot's "Physics," which may be obtained from The Technical Supply Co., Scranton, Pa. Price, $5.00. (*b*) We do not know of any such book. (*c*) It is impossible to tell from an indicator diagram just what is the most economical point of cut-off. (*d*) It would undoubtedly improve the economy of an automatic cut-off engine working under a variable load if the pressure of the steam in the steam chest could be so regulated as to prevent cut-off from taking place too early in the stroke. (*e*) It is our opinion that a very considerable portion of the water will soak away into the ground unless the reservoir is lined with a layer of watertight material. The best lining would consist of a layer of Portland cement concrete about 6 in. in thickness (a thickness of 3 in. might suffice for so small a reservoir). Either of the following would make a good concrete for this purpose, the proportions being in parts by measure: Portland cement, 1 part; sand, 3 parts; broken stone or gravel, 7 parts; or, natural cement, 1 part; sand, 2 parts; broken stone or gravel, 3 parts. Mix thoroughly dry, then add only sufficient water to give it the proper consistency. The concrete should be deposited in place promptly, and tamped thoroughly but lightly until a thin film of moisture appears on the surface. After it has set thoroughly, it should be given a coat of plaster composed of neat cement mortar. A layer of clay about 12 in. thick (6 in. might suffice) would also make a satisfactory lining. The clay should be

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moist enough to pack well when laid, and should be thoroughly rammed. (*f*) A reservoir 100 ft. square and 2 ft. deep would contain 125,000 gal. when about five-sixths full. In order that the ice can be cut to advantage, however, we would advise making the reservoir 3 ft. deep at least, and a depth of 4 ft. would be still better. The sides should slope not less than 1½ ft. horisontal to 1 ft. vertical. We do not think there would be any trouble about the water becoming stale in winter, especially in freezing weather.

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(237) I have a small dynamo the armature of which is wound with 1½-lb. No. 22 wire and the field with 4-lb. No. 18 wire. The machine is designed to run at 2,200 R. P. M. I have not been able to make this machine generate. The fields are but very weakly magnetized when connected to four bichromate cells. The field is of cast iron, of the form shown in the accompanying sketch. I would like to know what is the trouble with the machine. Would it help matters any to substitute wrought-iron pole pieces for cast-iron pole pieces?

C. K., Baltimore, Md.

ANS.—The sketch referred to shows a small two-pole Edison type machine with pole pieces 1¼ in. bore by 3 in. in length. The first thing to be done is to see that the fields are connected up properly. Looking down at the top of the machine, the coils should be connected up so that the current circulates around them in opposite directions. If the coils are connected all right and there is no break in the winding, four cells should make the poles fairly strong. They may also be tested with a compass to make sure that one is north and the other south. After the connections between the field coils are properly made, connect one terminal of the armature to one terminal of the field, and connect the remaining two terminals to a number of battery cells, and see if you can get the machine to run as a motor. If you can obtain current from a direct-current lighting circuit, so much the better, but be careful to put a resistance in series with the motor, to prevent too large a rush of current. First, get the machine to run satisfactorily as a motor; if this cannot be done, there is little use in attempting to run it as a dynamo. Then reverse the connections between the field and armature and try running it as a dynamo, driving it in the same direction that it ran as a motor. The resistance of the outside circuit must be low, and if the machine refuses to "pick up," short-circuit it at its terminals and see whether this has any effect. Some of these small machines, while they operate well enough as motors, give a great deal of trouble when an attempt is made to operate them as dynamos, because they are not capable of exciting their field magnets. Substituting wrought-iron pole pieces would not help matters enough to warrant the expense.

***

(238) I wish to know (*a*) the difference between the poundal and the pound system of units, and (*b*) how to find the efficiency of a machine referred to the two systems at different latitudes, as at Edinburgh, New York, and the equator.

C. D. P., Bird Island, Minn.

ANS.—(*a*) The poundal is the unit of force in the so-called "absolute system of units." In this system, a special lump of platinum kept somewhere in England is called the unit of mass; and the unit of force is that force which, acting unbalanced on the unit of mass, will impart to it an acceleration of 1 ft. per sec.; or, what is the same thing, will impart to it in 1 second a velocity of 1 ft. per sec. This unit of force is called the *poundal*. In the pound system, known as the "gravitation system of units," the unit of force (the pound) is the weight at a certain place (say at London) of the lump of platinum referred to above; but this lump of platinum is not taken as the unit of mass, no unit of mass being necessary in this system. If the weight (determined by a spring balance) of a body at any place is W, and the acceleration due to gravity is g, the mass of the body is defined as a name given to the quotient $W \div g$. If the acceleration due to gravity is g_0 at London (or wherever the weight of the lump of platinum is taken as the unit of force), then 1 pound $= g_0$ poundals. If the weights (determined by a spring balance) at London and at a place where the acceleration of gravity is g are W_0 and W pounds, respectively, we have $W = W_0 \frac{g}{g_0}$ pounds $= mg$ pounds, denoting the mass $\frac{W_0}{g_0}\left(= \frac{W}{g}\right)$ by m. If the weight in poundals is W', we have $W' = Wg_0 = mgg_0$. In practice, the difference between W_0 and W is neglected; that is, g is taken as equal to g_0, and then $W' = Wg$, and, in general, any force expressed in pounds is converted into poundals by multiplying by g. When the variations in the value of g are to be taken into account, the following formula may be used, where g is the acceleration of gravity in feet per second, at a place whose latitude is l and whose height above sea level is h feet: $g = 32.173 - .0821 \cos 2l - .000008\,h$. For accurate calculations, however, the exact value of g at any particular place is determined by means of a pendulum. (*b*) The efficiency of a machine is the ratio of the work expended on it and the useful work done by it; and is, as all ratios are, entirely independent of the units used.

***

(239) State how prints are made, having the ground white and the lines of the drawing blue.

E. A. B., Kansas City, Mo.

ANS.—This process was fully described in the November, 1898, issue of "Home Study Magazine."

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(240) (*a*) Please give me the name of some book, pamphlet, or article on water gas. (*b*) Please give the relative heating values of alcohol, gasoline, crude petroleum, coal oil, Pintsch gas, producer gas, acetylene, and carbon; the number of heat units (B. T. U.) that will be developed by the combustion of a pound of each; and the number of pounds of water each will raise from 32° to 100° F. G. W., St. Louis, Mo.

ANS.—(*a*) "Engineering Chemistry," by Thomas B. Stillman; price $4.50. "Kent's Mechanical Engineer's Pocketbook"; price $5.00. These books may be obtained from The Technical Supply Co., Scranton, Pa. Considerable information regarding water gas and its manufacture can also be obtained from a paper entitled "Fuel Gas and Its Applications," which appears in Vol. XIX of "The Transactions of the American Institute of Mining Engineers." It is probable this paper can be obtained in pamphlet form; for particulars regarding it, address R. W. Raymond, secretary, the American Institute of Mining Engineers, 18 Burling Slip, New York City. (*b*) The number of heat units that will be developed by combustion of a pound of carbon is about 14,500. Of the other substances named, authorities differ regarding the heating value. In most cases the differences in composition and physical properties of the commercial grades are great, and in consequence different experimenters have obtained results that differ very materially. Average values for the number of B. T. U. that will be developed by the perfect combustion of 1 pound of each of the different substances, as determined by the best authorities we have at hand, are as follows: Alcohol, 13,000; gasoline, 11,000; crude petroleum, 18,000; coal oil (kerosene), 20,000; producer gas (Siemen's), 1,500; producer

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gas (semiwater gas), 2,200; acetylene, 21,500. We have no data regarding the heat value of Pintsch gas. The number of B. T. U. required to change the temperature of a pound of water from 32° to 100° F. is slightly more than 68; by dividing the theoretical heat of combustion by this quantity, the theoretical number of pounds of water that will be heated from 32° to 100° will be given. The practical effect of the combustion of a pound of a given substance will depend on the conditions under which it is burned.

***

(241) Please show me how to figure the change gears for a simple-geared lathe.

H. N. P., Cincinnati, Ohio.

ANS.—A method of determining gears is given in the March, 1900, issue of SCIENCE AND INDUSTRY, Answers to Inquiries, No. 77.

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(242) (*a*) Can wood be used for the piston of a gasoline engine? If so, should it be treated with any substance? (*b*) How can I galvanize small things, such as nails, screws, etc.? (*c*) Can you give me the names of men that buy undeveloped natural gas and oil chances? S. T., Houston, Tex.

ANS.—(*a*) We have never known of the use of wood for this purpose, and do not think it could be used successfully. The high temperature in a gas-engine cylinder would quickly char the wood and destroy its strength, no matter how treated. (*b*) Clean all scale, rust, dirt, or oil from the surface, and if oily, boil in caustic soda, and then remove the scale and rust by a bath of hydrochloric acid and water. If necessary, scrub the article a little with a metallic brush, and then thoroughly rinse in hot water and dry quickly. After drying immerse in a bath of melted zinc, and at the same time sprinkle a little powdered ammonium chloride on the surface of the melted zinc to clear it. Very small pieces require only a few seconds of immersion. (*c*) We cannot furnish this information.

***

(243) We have a No. 12 galvanized-iron wire running parallel on the same poles for about 1 mile, with wires carrying current at a high voltage, and it also runs under and above, at different places, some trolley feeders and street-lighting wires. Its entire length is 4 miles. We use this wire for telegraphing from 7:00 A. M. to 6:00 P. M., and then it is cut off entirely from the telegraph instruments, and a telephone of a good make switched on at each end. We cannot hear well with them, however, for, as soon as we take down the receiver, a terrible roaring occurs, which, I think, is caused by induction from the above wires. Am I right, and is there any way to prevent this roaring without erecting another wire to make it a metallic circuit?

C. H., Edgemoor, Del.

ANS.—Yes, you are right; the noise is due to the induction from the other wires. You may perhaps overcome the trouble by making the mile, where it runs parallel and on the same poles with the high-voltage wires, complete metallic, transposing every 800 ft. or oftener. If this does not improve it sufficiently, you will have to make the entire line a complete metallic circuit, and transpose frequently. There is no other way.

***

(244) Is there any rule for dividing a circle into any number of equal parts, or inscribing a regular polygon of any number of sides in a given circle? If so, please state how it is done.

G. M. M., Takoma Park, D. C.

ANS.—In elementary theoretical geometry it is permissible to use only constructions that can be made by means of a pair of compasses and an ungraduated straightedge. With this restriction it is possible to inscribe, in a given circle, a regular polygon whose number of sides is the product of 2^n and one or more different primes of the form $2^m + 1$, where n and m are integers; and it is impossible to construct geometrically any other regular polygon. This very important proposition was proved by the celebrated mathematician Gauss. According to this proposition, it is possible to construct geometrically a regular polygon having 3, 4, 5, 6, 8, 10, 12, 15, 16, 17, 20, 24, 30, 32, 34, 40, 48, 51, 60, 64, 65, 68, 80, 85, or 96 sides; these are the only regular polygons of less than 100 sides whose construction is possible. The constructions for several of these are given in most textbooks on geometry, but we have not space to give them in this column. In practice, it is best to divide the circumference into the required number of equal parts by trial, using the dividers.

***

(245) I have a galvanometer and would like to make a Wheatstone bridge. Please give me some particulars for my guidance. (*a*) I have some No. 30 cotton-covered wire; will this do for the resistance coils? (*b*) What size coils and how many should I make in order to have a bridge suitable for practical work? W. J. M., Apollo, Pa.

ANS.—(*a*) The No. 30 wire will answer if it is of German silver. It would hardly answer if of copper, because it would take a great length of it to make up the coils, and besides its resistance would vary too much with changes in temperature. (*b*) For the adjustable arm of the bridge you should have coils as follows: 1, 2, 2, 5, 10, 20, 20, 50, 100, 200, 200, 500 ohms. It would also be desirable to have a 1,000-ohm coil, if possible. The adjustable arms may consist of three coils, each of 1, 10, and 100 ohms. Wind the coils on hardwood spools soaked in paraffin and wind the wire double; i. e., wind two wires side by side and join the two ends, where the coil was started, together, using the other two ends as the terminal of the spool. This amounts to the same thing as doubling the wire on itself and then winding on the spool. By winding the coils in this way, inductive effects are avoided. After the coils are adjusted and connected up, dip them in paraffin so as to keep out moisture.

***

(246) What are screw piles, how are they constructed, and for what purpose?

C. A. E., Baltimore, Md.

ANS.—A screw pile is a pile having a short metal screw or helicoidal flange at the bottom, by means of which it is screwed into soft or muddy soil. Screw piles are sometimes composed of wood with metal screws, but more commonly consist wholly of metal. Metal screw piles are used extensively by the government in submerged work, such as lighthouse foundations.

***

(247) (*a*) Is there any machine other than the common surface grinder for grinding the flanges on stove plates? (*b*) What kind of a machine is mostly used for this purpose? (*c*) Are there any upright machines? P. W. D., Lebanon, Pa.

ANS.—(*a* and *b*) We believe that in small places they use the ordinary emery wheel, grinding by hand. (*c*) Not that we know of—at least not in the market.

***

(248) Will four "Mascot" dry batteries operate the telephone instruments on a private line three-fourths of a mile in length, using a metallic circuit?

E. W. H., Andover, O.

ANS.—Two cells at each end will be sufficient to operate the microphone transmitters. For this purpose, some form of a wet cell, such as a Leclanché, would be better. If you are going to use them for ringing up, at least three or four cells will be necessary at each end. Dry cells will do very well for this purpose.

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SCIENCE AND INDUSTRY

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CONSTRUCTION OF A MERCATOR'S CHART

Ernest K. Roden

POPULARITY AND PECULIARITY OF THE MERCATOR'S CHART—MERCATOR'S ORIGINAL SYSTEM. WRIGHT'S DEMONSTRATION—HOW TO CONSTRUCT AND USE A MERCATOR'S CHART

A MAP of the world on Mercator's projection is a very common thing nowadays. It is to be found anywhere: in the luxurious offices of the great financier as well as in the less elaborately decorated office of the junk dealer; on the walls of every college, school, and kindergarten; in the homes of rich and poor; everywhere can be found evidence of the great popularity of this chart. In fact, it gives an observer the impression that it is used more for a decoration than anything else.

Looking at a Mercator's chart representing the world, without being familiar with the peculiarity of its construction, the beholder is particularly struck with the immense tracts of land abounding above the sixtieth parallel of north latitude. The area of Greenland appears to be about one-third larger than the United States, and the islands of Spitzbergen appear twice as large as the Kingdom of Spain. Undoubtedly, many persons think that such is in reality the case, arguing that charts are not printed "with lies on their face." Now, we are obliged to confess that, whatever the merits of a Mercator's chart, it certainly cannot be said to be truthful—at least not in the higher latitudes. Greenland is not as large as the United States; in fact, the area of Greenland is not any greater than that of Mexico, and the area of the Kingdom of Spain is at least five times as large as that of the islands of Spitzbergen. Why, then, should charts or maps that are erroneous and misleading be printed and distributed for sale? Is it because of the old saying that the public at large, as a general rule, enjoys the privilege of getting fooled? No, it is not; the reason for this apparent irregularity of the Mercator's chart will be explained as we proceed.

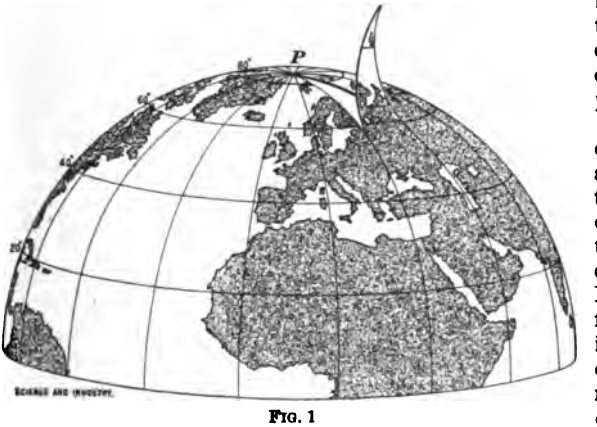

FIG. 1

Charts, Mercatorial or not, are representations of the earth, or portions of the earth's surface. Now, since the form of the earth is globular, it is evident that any representation of its surface on a flat sheet of paper, such as a chart, must necessarily be an artificial construction—or, in other words, a projection of the globe upon the paper. In order to insure a true representation of the original, there are certain conditions that must be fulfilled, viz., *conformity*, *equivalence*, and *equidistance*. Conformity requires that each figure of the image shall possess a geometrical similarity to the original; that is, all corresponding angles must be equal. Equivalence requires that the area of certain spaces on the chart shall have the same ratio to one another as

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the corresponding spaces on the surface of the earth. Equidistance requires that the distances from any two points to the center of the chart shall have the same ratio to each other as the corresponding distances on the earth.

The spherical representation of the earth (the globe) is, however, the only image that can satisfy all of these conditions. But a globe is a very inconvenient thing on which to find distances, bearings, and areas. Therefore, when representing some part of the earth's surface on a plain sheet of paper, the constructor will have to content himself with strictly satisfying *one* of these conditions, while the others are satisfied as near as they possibly can be. This may be accomplished in several ways by applying the rules of different methods of projection. Among these, used for map and chart construction, the *polyconic*, the *gnomonic*, and *Mercator's* projection are prominent. In simplicity and general handiness, the last named is foremost.

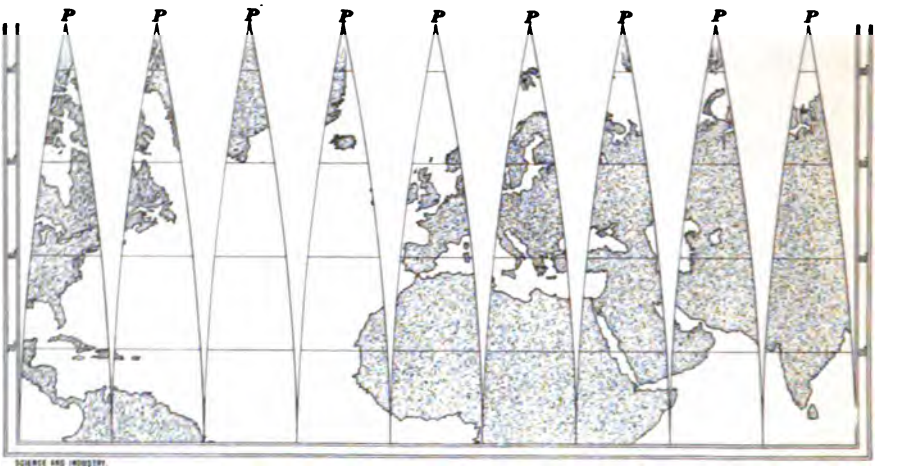

FIG. 2

The inventor of this system was Gerard Mercator, which is the Latinized form of his real name, Krämer. Mercator was born at Rupelmonde, Flanders, in 1512, and died in 1594. He was educated at Bois-le-Duc, and later took a degree in philosophy at the University of Louvain, after which he made a profound study of the science of geography and mathematics. In 1559 he was appointed a cosmographer to the Duke of Cleve. His system was not strictly a projection, but may be said to have resulted from operations

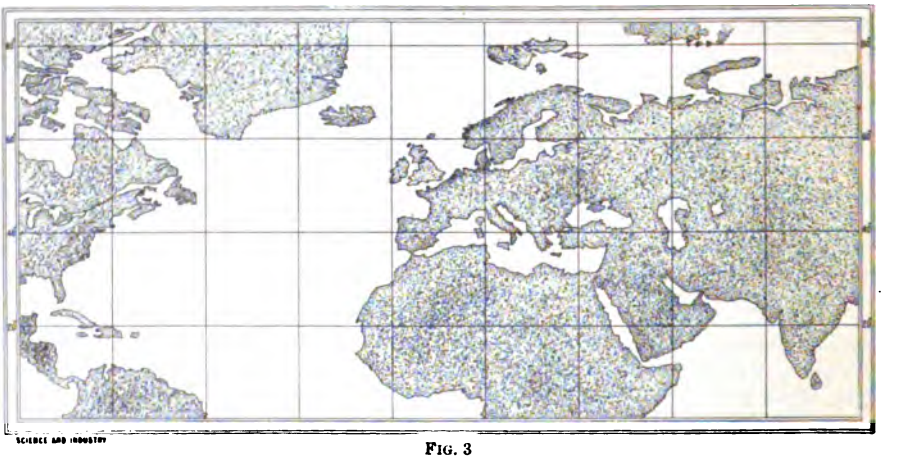

FIG. 3

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illustrated in Figs. 1, 2, 3, and 4. By stripping the gores formed by the meridians off the globe (Fig. 1) representing the northern hemisphere, a chart is formed similar to the one shown in Fig. 2. Owing to the openings, or vacant spaces, between the meridians, this chart is very defective; and, in order to remedy this defect, the upper parts of the gores are stretched so as to form the chart represented in Fig. 3. A glance at this chart, however, will reveal the fact that everything on it, except the equatorial parts, the necessity of satisfying, as far as possible, the conditions of conformity, equivalence, and equidistance, the intelligent reader will hardly fail to comprehend why the peninsula of Greenland looks larger than the United States, and why the area of the Kingdom of Spain appears insignificant in comparison with the islands of Spitzbergen.

Mercator did not demonstrate mathematically the principles of his system. Toward the close of the 16th century, however,

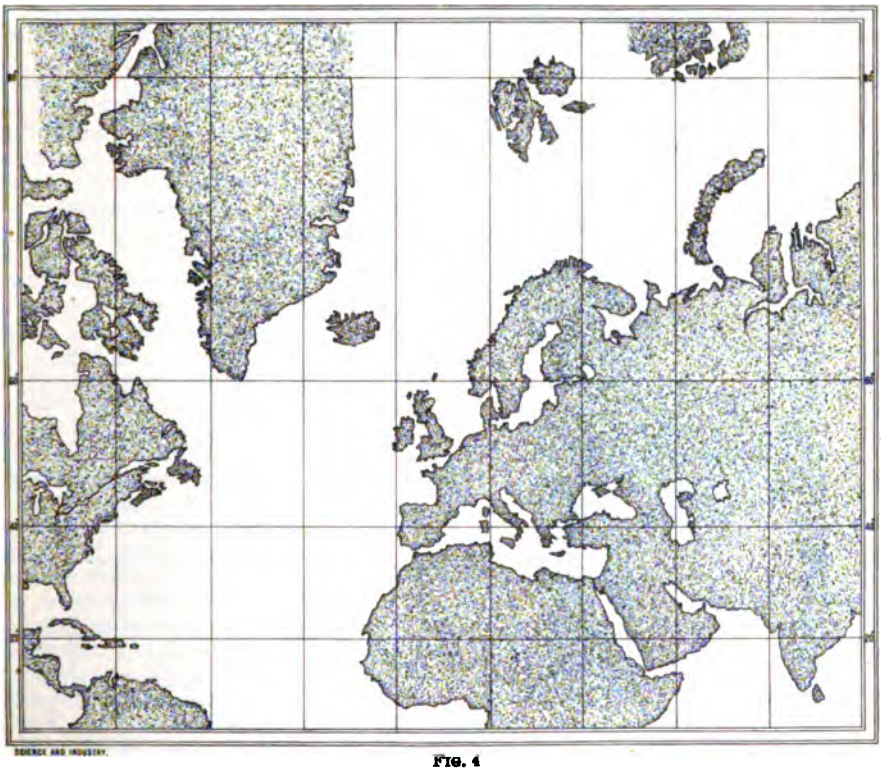

FIG. 4

are distorted, and that this distortion increases in the higher latitudes. Now, in order to restore a balance of orientation, or the relative position and direction of spaces, which are distributed *horizontally* (or in longitude), it is essential to distort the chart in an equal proportion *vertically* (or in latitude). When this has been done, the result is as shown in Fig. 4, which represents a complete map of half the northern hemisphere according to Mercator's system.

On account of this distortion of the Mercatorial chart in the higher latitudes, due to Edward Wright, an English scientist, gave a mathematical demonstration of the law on which Mercator constructed his chart; at the same time he rendered a graphic explanation of the principles underlying its construction. He assumed that a cylinder contained a spherical globe representing the earth, Fig. 5 (*a*), which was to swell like a bladder, equally in latitude and longitude, until it coincided with the concave surface of the cylinder; at the same time the meridians widen out until they are everywhere the same distance from each other, as on the equator. In this way the spherical surface

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is made to coincide with the cylindrical concave surface. Cutting the cylinder down a meridian, and opening it out into a flat surface, Fig. 5 (*b*), we shall find on it a representation of a Mercator's chart. For this reason, all the meridians are parallel straight lines, and the degrees of longitude are all equidistant; the latitude parallels are everywhere at right angles to the meridians; and hence the loxodromic line, or track of a ship that steers a straight continuous course, or the relative direction between two places, can be represented on a Mercator's chart as a straight line. Consequently, this chart satisfies the first condition, conformity—the ence of latitude, is known as the *meridional difference of latitude.*

Many of our readers possibly think that the construction of a Mercator's chart is a very difficult and complicated problem, and something that cannot be mastered by the average man. We will, however, proceed to show that the problem, instead of being difficult, is very simple and easy. All that is needed is a table of meridional parts, which is to be found in any collection of mathematical or astronomical tables, and the usual outfit of drawing materials. The order of procedure is then as follows: First determine the limits of the proposed chart

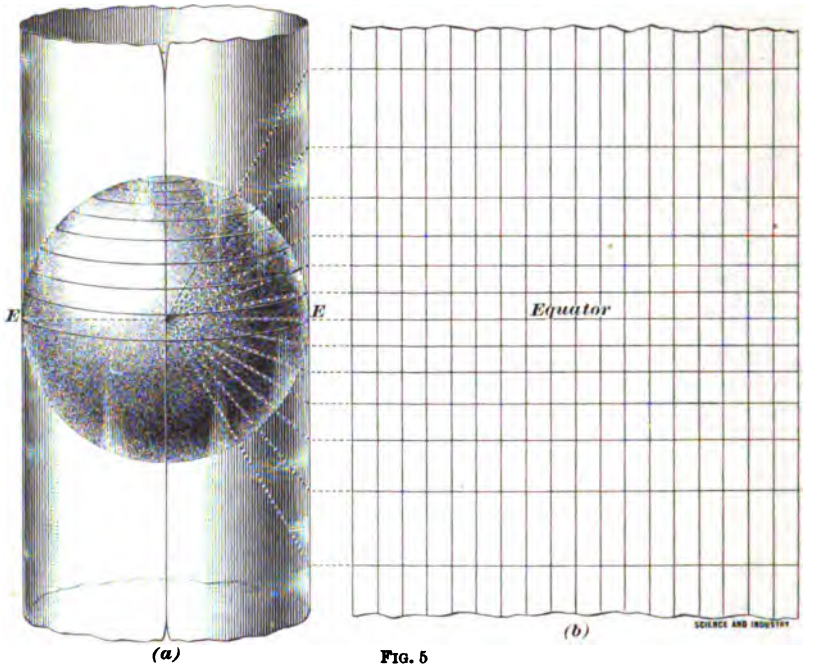

FIG. 5

other conditions being satisfied to a great degree of accuracy. The degrees of latitude are all unequal, being *increased* in length from the equator to the pole, in the same proportion as the degrees of longitude *decrease* on the globe. The lengths of the small portions of the meridians thus increased, expressed in minutes of the equator, are called *meridional parts;* and the meridional part for any latitude is the line expressed in minutes of the equator into which the latitude is thus expanded. The length of the line on a Mercator's chart, or the difference, for any two latitudes, between the meridional parts, which represents the differ—in others words, the number of degrees and minutes it is to contain, both of latitude and of longitude. Then draw a straight line near the *lower* margin of the paper if the chart is to represent north latitude; near the upper margin if it is to represent south latitude; or at a suitable position toward the center if both north and south latitude are to be represented. Divide this line into as many equal parts as the number of degrees of longitude required; for instance, if the chart is to contain 15 degrees of longitude, divide the line into 15 equal parts. At each extremity erect lines perpendicular to it. Take out from the tables (referred to

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before) the meridional parts for each convenient degree of latitude, for the limits between which the chart is to be drawn, and take the difference between each successive pair, thus obtaining the meridional differences of latitude. Reduce these meridional differences to degrees, by dividing them by 60; the result will be the lengths on the longitude scale between the chosen degrees of latitude. Lay off these lengths successively on the perpendicular lines, and through the points thus obtained draw straight lines parallel to the original line, to represent latitude parallels. At convenient intervals, or through each division on the base line, draw lines parallel to the perpendiculars to represent meridians. The accuracy of the frame of the chart thus completed should be tested by measuring the two diagonals of the rectangle formed; if they are of the same length, the frame is perfect. The principal points in the chart are now laid down according to their respective latitudes and longitudes; and whatever formations and contours of water or land required, together with other useful items, are drawn in freehand. A compass diagram may also be inserted, but it should be remembered that the direction of the meridians indicates true north and south.

In order to illustrate the foregoing, let it be required to construct a chart on the Mercator's projection, extending from latitude 40° N to 43° N, and from longitude 74° W to 77° W, on a scale of 2 inches to 1° of longitude.

In order to do this, draw a horizontal line $a\,b$, Fig. 6, at the bottom margin of the paper, to represent the fortieth parallel of latitude. On this line, lay off three lengths of 2 inches each, and divide each length into 60 equal parts, representing geographical miles. At the extremities of the line, carefully erect the perpendiculars $a\,c$ and $b\,d$, to represent meridians. Then consult the table of meridional parts, and take out the values corresponding to each degree of latitude, and obtain the differences as indicated below:

Lat.	M.P.	M.D.L.	
40°—2,607.9	}	78.6 ÷ 60	= 1° 18.6′
41°—2,686.5	}	79.8 ÷ 60	= 1° 19.8′
42°—2.766.3	}	81.1 ÷ 60	= 1° 21.1′
43°—2,847.4			

This complied with, take, with the dividers, 1° 18.6′ from the scale of longitude, and lay it off on each perpendicular from the base line, and through the points thus obtained draw the parallel of 41°. In like manner, from the parallel of 41°, lay off 1° 19.8′, and draw the parallel of 42°. Proceed similarly, and get the parallel of 43°. Divide this last parallel into degrees and minutes, the same as the parallel of 40°, and draw the meridians of 75° and 76° west longitude. The result will be as shown in Fig. 6, representing a chart on Mercator's projection according to the limits required.

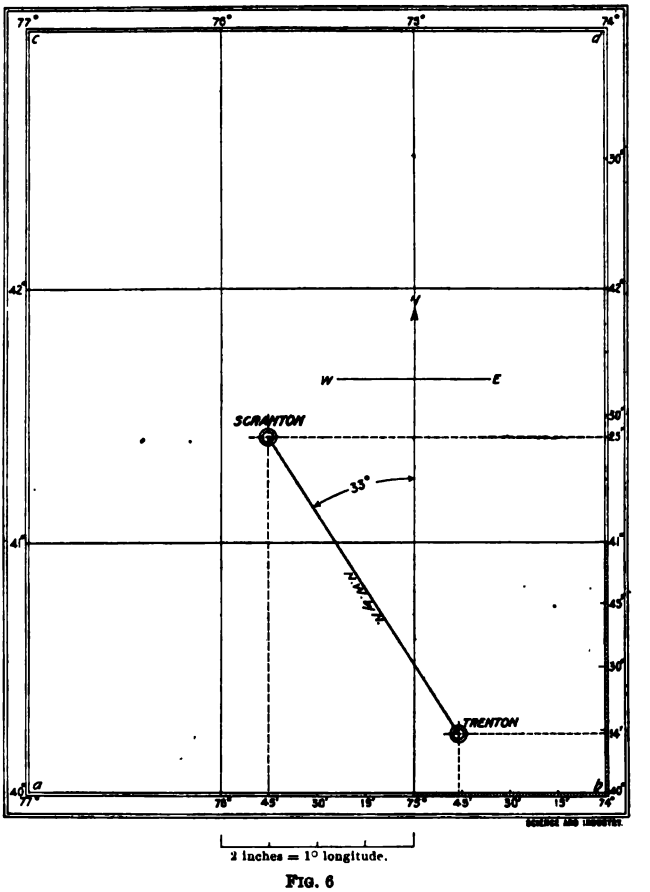

FIG. 6

Now, to demonstrate the usefulness of the Mercator's chart, let us assume that we are

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50 years ahead of the present time—that is, in 1950—when, in all probability, air ships will be as common as the bicycle of today. You are in Trenton, N. J. (Lat. 40° 14′ N, Long. 74° 46′ W), but urgent business requires your immediate presence at Scranton, Pa. (Lat. 41° 25′ N, Long. 75° 45′ W). Your air ship is in good condition, and you decide to take the shortest possible route in order to reach Scranton. Unfortunately, your map of Pennsylvania and New Jersey is lost, but a table of meridional parts, drawing materials, and a compass is at your disposal; you are also acquainted with the latitude and longitude of both places. All that has to be done now is to construct a chart similar to the one represented in Fig. 6, and mark down on it the positions of Trenton and Scranton, and connect the two places by a straight line. The angle that this line makes with one of the meridians will be the course you have to steer in order to reach Scranton in the shortest possible time. Measuring this angle, we find it to be 33° west of the meridian; hence, the course from Trenton to Scranton is N 33° W, or *northwest by north*. The correctness of this may be verified on any chart the reader may possess.

From what has been shown, it is evident that by the aid of a table of meridional parts, the construction of charts on Mercator's projection is quite simple, and can be mastered by any one that has a knowledge of drawing and simple arithmetic. From the nature of its construction, however, the inexactness of the Mercator's chart fully reveals itself in high latitudes, and for this reason is quite impracticable for polar navigation. In high latitudes, therefore, charts are not constructed on the Mercator's projection, but on the gnomonic projection, which is splendidly adapted for maps of the polar regions.

THE TWELFTH CENSUS

WITH the first of June of this year the Twelfth Census begins. This is an event of deep significance in the history of national development and progress. Man is a gregarious animal; and ever since Cain proposed the question, "Am I my brother's keeper?" man as an individual has felt a deep interest in man as a member of the human family. Perhaps the best means of estimating the degree of civilization attained by a country is found in the importance attached by its people to this national inventory, or taking of stock. No man engaged in business, if he has any of those instincts without which success is impossible, would think of omitting a regular annual inventory. The merchant whose competition no rival fears always omits this business formality; and the chief difference between Prometheus and his fatuous brother Epimetheus was in this stock-taking instinct. Nobody knows anything to speak of about China—the population of her cities, her industries, education, and various activities. Hardly had Japan's Renaissance come when she began to measure her progress by instituting a government census. The absence of complete industrial, social, and political statistics is proof positive of savagery or semicivilization.

The enumerators, whose duty it is to ask us so many questions that seem impertinent, have a hard time of it, and their experiences have always furnished the material for many laugh-provoking newspaper paragraphs; but no person of real intelligence would even think of resenting any of their inquiries any more than a wise business man would of becoming angry when questioned by a representative of Bradstreet. These officials are subject to a severe penalty for any failure to treat all census material as confidential, and no one should hesitate to answer frankly and truthfully, even though the questions were much more minute and searching than they are. Just what these questions are is clearly indicated in the circular issued to enumerators. The writer has carefully examined this circular, and he can positively state that not one question seems to him superfluous or really impertinent. Each question is intended to elicit information that any good citizen would be better for knowing. The census authorities need never expect to have any difficulties with persons of education or intelligence; anger, untruth, and evasion on the part of any one when questioned in the manner proposed by the government, furnish excellent proof of ignorance, stupidity, and the absence of public spirit and a proper sense of political obligation. Such resentment should hurt a man's reputation for good sense as much as a public admission of his belief in witchcraft.

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HOW TO MAKE A STORAGE BATTERY

R. B. Williamson, M. E.

PREPARATION OF LEAD PLATES—APPLYING THE ACTIVE MATERIAL—TYPE OF BATTERY JAR. MOUNTING PLATES IN JAR—CHARGING

THERE is much more work connected with the making of a storage battery than with the making of an ordinary primary cell. For this reason, storage batteries are more expensive than primary batteries, and the amateur is all the more anxious on this account to make them for himself, aside from the knowledge gained by doing so. It may be said at the outset that, if one counted time as worth anything, it would be as cheap to buy the cells as to make them; but the amateur usually considers time as of no consequence if he can make a cell that will work satisfactorily.

The cell we will describe has what is known as *pasted* plates; i. e., the active material is applied to the lead plates of the battery in the form of a paste, instead of

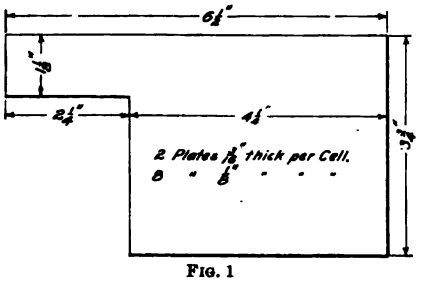

FIG. 1

being built up by repeatedly charging and discharging. Cells made by both processes are in common use, and each kind has its peculiar advantages and disadvantages. It would, however, be out of place to take these up in connection with this article.

About 13 pounds of lead per cell will be required. This should be in the shape of sheet lead, as in this form it may at once be cut up into the plates required. In this cell it is necessary to have the two end plates $\frac{1}{16}$ inch thick, while the center plates need be only $\frac{1}{8}$ inch thick. If sheet lead is used, a sufficient amount of $\frac{1}{16}$-inch sheet should be obtained to make two plates for each cell. Fig. 1 shows the shape of the plates. The main part is $3\frac{3}{4}$ in. $\times$ $4\frac{1}{2}$ in., and a tongue $1\frac{1}{8}$ in. $\times$ $2\frac{1}{4}$ in. is provided for attaching the plates to the terminals. For each cell two thick plates and eight $\frac{1}{8}$-inch plates will be required. In cutting out the plates it is best to lay them out as shown in Fig. 2, in order to avoid waste of material. One side of each of these

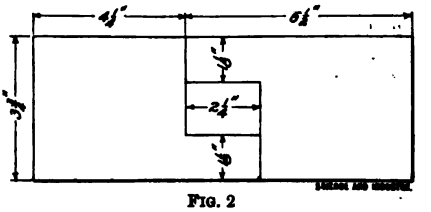

FIG. 2

plates must now be roughened, in order to make it hold the active material. To make sure that the proper sides of the plates are roughened, we will refer to Fig. 3, which shows the relative arrangement of the plates in the cell, as viewed from the top. It is not possible to roughen both sides of the plates by the method described later, because the roughening up of one side would flatten out the other; for this reason the middle plates are made up of two thinner plates, placed back to back, as shown. It is best to make up the plates in pairs, and then no confusion will result as to the proper side to be roughed up to bring the lugs in the right position.

The plates may be roughened up as follows: Procure an old wood chisel that is anywhere from $\frac{1}{2}$ to 1 inch in width; draw the temper by heating it carefully to a dull red heat, and allow it to cool slowly. After this has been done, file some nicks in the edge by means of a three-cornered file, and the result will be a tool similar to that shown in Fig. 4. The nicks should be rather coarse; about $\frac{1}{8}$ inch between centers will answer quite well. Take a good solid block of wood that is perfectly flat, and nail a cleat across it as shown in Fig. 5; place the bottom of the plate against the cleat, and on the upper side

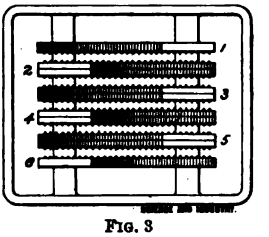

FIG. 3

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place the surface to be nicked. The block should either be screwed to the bench or held by a carpenter's clamp. Be sure that you have the proper side of the plate up before you begin, and also be sure that the bottom end of the plate is against the cleat as shown. If these points are not watched, you may find that by the time the plate is completed you have the wrong side nicked and that it will not correspond to the other plates for the cell. Start at the bottom of the plate, hold the tool at an angle a little less than 45° with the bench, and by means of a mallet drive the tool into the lead. Do not drive the tool in more than about one-third the thickness of the plate; and before withdrawing it tilt it up by an upward swinging motion of the arm. This will force the lead out, and make the pockets larger than if the tool were simply driven in and then withdrawn. Draw the tool back an equal distance after each cut, until

FIG. 4

FIG. 5

a row of cuts has been made the whole length of the plate; another row may then be started, and so on until the plate is completed. The cutting should be done neatly and uniformly, so that the plate will have much the appearance of a coarse rasp file after it is finished. These nicks all point upward when the plates are stood on end in the cell, and they will thus retain the active material placed in them. In nicking these plates, care should be taken not to cut them too deep, or the plate may be so weakened that it will warp out of shape when used in the battery.

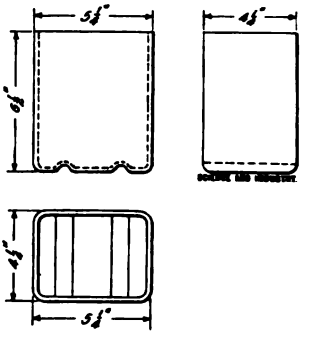

FIG. 6

After the plates have all been nicked as described above, the next step is to apply the active material to them. The material for the positive plates is red lead, or minium Pb_3O_4. This should be made up into a stiff paste, using dilute sulphuric acid to mix with it. The paste may be rubbed into the pockets on the plate with a flat stick by placing some of the paste on the plate and drawing the stick from the top toward the bottom. This process should be continued until the plate is evenly covered with the material and all the pockets filled. Plates *1*, *3*, *5*, Fig. 3, should be filled with this material. The paste for the negative plates is made of litharge *PbO* (lead oxide), made up into a thick paste with sulphuric acid as before. Plates *2*, *4*, and *6*, Fig. 3, are treated with this paste, thus making three positive and three negative plates per cell. After the plates have been coated, they should be allowed to dry slowly until the paste becomes perfectly hard. It will not do to dry these plates too fast, because if this is done the material is apt to crack and become loose.

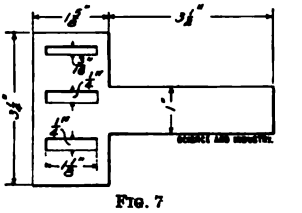

FIG. 7

The plates are now prepared and ready to be mounted in the glass jar. The best kind of jar for this purpose is the regular storage-battery type, which is rectangular in shape, although almost any style of jar might be used. We will use a standard

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battery jar like that shown in Fig. 6. These jars are about 4¼ in. × 5¼ in. × 6½ in., and have two ridges in the bottom, on which the plates rest. This allows any material that may fall off the plates to accumulate in the bottom of the cell without short-circuiting it. These jars may be obtained through electrical supply houses; they cost about 25 cents each. The plates should be arranged in the cell in the order shown in Fig. 3, and should be held in place by strips of hard rubber or by glass rods placed between them; the hard rubber is preferable, as it does not break so easily. The plates should just be wedged tight enough to hold them in place between the end walls of the jar. There is no need of very tight wedging, as it is only liable to break the jar, and, besides, the lead terminals to be put on

FIG. 8

later help to hold the plates in place. The plates should be spaced about equally, and there should be room for about $\frac{1}{16}$ or ¼ inch clearance between them. This clearance will depend largely on how the plates have been roughened; the main thing to look out for is to see that none of the plates come so close together that there is any danger of touching.

After the plates have been arranged in the cell they must be connected together by means of lead terminal pieces. Two pieces, of the shape shown in Fig. 7, will be required for each cell. These should be cut out of $\frac{1}{16}$-inch sheet lead, and should have three slots cut in them, as shown, to receive the lugs on the plates. The openings in the terminals should correspond to the lugs on the plates, although the latter may be easily bent into place if they do not match exactly. The lugs on the plates should now be trimmed off until they are of the same height, and the terminals should be fitted over them so that the lugs pass snugly through the slots and

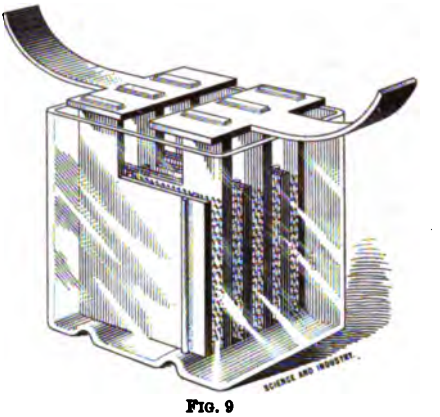

FIG. 9

come about ⅛ inch above the upper surface. When this has been done, the terminals and lugs should be "burned" or soldered together. Burning is by far the better method, but unfortunately it is not an operation that is easily performed unless one has had a certain amount of experience. It consists in fusing the lead at the point where the plates are to be united, and, unless an expert in the use of the blowpipe, one is apt to melt a large portion of the plate.

The terminals may be burned on as follows: Thoroughly clean the holes in the terminals, and also that part of the lug which projects through the terminal plate, and scrape the upper surface of the terminal plate

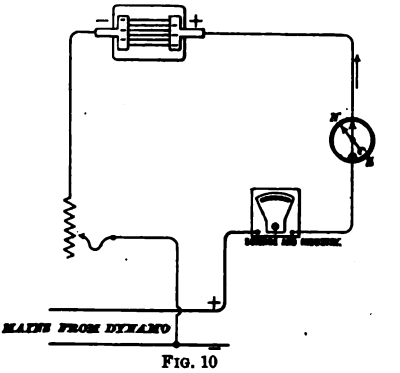

FIG. 10

for about $\frac{3}{16}$ inch all around the lugs, as shown in Fig. 8. Use a small gas flame, as shown, and with a blowpipe melt down the part of the lug that projects above the

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terminal plate. If this is properly done, the lug and the terminal plate will become fused together, thus making a strong joint and a good electrical contact. In burning the joint, Yeager's soldering salts should be used as a flux.

Soldering is more easily carried out, but it does not make as permanent a job; however, it will work all right for a long time if it is well done. Resin may be used as a flux. Care must be taken in handling the soldering iron, or, by the time the terminals are soldered on, a good part of them will be melted out of shape. After the terminals have been attached, the cell is complete so far as its mechanical construction is concerned. Fig. 9 shows the finished cell. The lugs form the terminals of the cell; and if a number are to be connected together, the positive terminal of one cell is connected to the negative of the next by burning these lugs together. Binding posts are not used, because they become corroded in a short time.

The cell is now filled with the electrolyte, which is composed of 1 part by weight of sulphuric acid to 2 parts of water. The specific gravity of the solution should be between 1.17 and 1.20. It is well to test this if a hydrometer can be obtained, because the satisfactory performance of the cell depends very largely on the proper density of the electrolyte. If the density is low, more acid should be added; if too high, it should be diluted with water. The liquid should come well over the tops of the plates, so that the main part of the plates will be entirely submerged.

The last thing to be done is to charge the battery. The plates to which the red lead was applied form the positive pole of the battery, or the pole from which the current will flow when the battery is discharging. When the battery is being charged, it must be connected so that the charging current will flow in at this pole; i. e., the positive pole of the battery must be connected to the positive pole of the dynamo or to the positive side of the line from which the battery is charged. The connections for charging are shown in Fig. 10. The proper direction of the current may be ascertained by means of a compass held under the wire connected to the positive pole; the north end of the needle will swing toward the left. An ammeter and adjustable resistance should also be included in the circuit, in order that the current may be properly regulated. The charging current should be adjusted to about 2 amperes, and the cells allowed to charge up fully. The positive plates will gradually become dark brown in color, and the negative plates will take on a grayish tinge. When the cells have become fully charged, they will give off gas freely, and it will probably take at least 10 or 12 hours to bring them to this condition.

The capacity of a cell made as described above is about 3 amperes for 6 hours, at an average pressure of about 2 volts. Of course, the cell will give a larger current than this for short intervals, but it is not advisable or economical to draw heavy currents from the cells, as it materially shortens their life. A battery of ten of these cells should be capable of running a 16-candlepower 20-volt lamp for about 5 hours. The same battery would run a $\frac{1}{12}$-horsepower motor for about 5 hours. Should it be necessary to secure a larger current output than 3 amperes, the cells may be connected in parallel when discharging, thus adding the current output of each group. The price of a commercial form of cell of this capacity is about $3.75, and the materials for making the cell described would probably cost in the neighborhood of $1.75 or $2.00, assuming that sheet lead is worth 8 cents a pound.

In connection with the construction of this battery it may be mentioned that, if it is not possible to procure rolled lead for the plates, they may be cast. The cast plate is not of as good quality, as it is not so dense or so even as the rolled plate; but if care is taken a good plate may be made by casting it, and thus utilizing comparatively inexpensive scrap metal. Ordinary round battery jars may also be used, the plates being held together by heavy rubber bands, instead of being wedged against the jar. If a flat-bottomed jar is used, a couple of pieces of heavy glass rod should be laid in the bottom, in order to raise the plates so that they will not be short-circuited by any dirt that may accumulate. The battery will work just as well in the circular jar, but it will occupy more space—hence the reason for using the rectangular jars.

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STEAM PIPING

Chas. J. Mason

PIPING IN GENERAL—IMPORTANCE OF DESIGN—IRON PIPING—BRASS PIPING—COPPER PIPING. FITTINGS

THE piping of steam plants apparently does not receive the amount of consideration and attention that its importance demands. Engineers and others concerned in the installation of plants, or the remodeling of those already in existence, seem to give their attention mostly to everything else but the piping—anything and everything (except it be *grievously* wrong) seems to be passable until the evil effects show up on some future occasion, perhaps when the time to make the necessary repairs or alterations can be ill afforded. Usually, in such cases, the part affected is hastily renewed to bridge over a certain period, which may perhaps be extended beyond its due limits owing to other happenings in the plant requiring attention; and so, time after time, when occasion demands, alterations and complete changes must be made to meet the requirements and conditions not taken into consideration at the outset. Of course, the writer is aware of the rule of exception, for there are plants where the piping has been carefully considered even to the smallest detail, and it is noticeable, in such places, that the constant services of a steam fitter are not required. If, in the first place, the piping is properly designed, the proper material used, and lastly, the proper care given it, why should it be constantly tinkered with, taken down, and altered?

Of course, new conditions may arise or new requirements come into existence that will necessitate alterations and extensions entirely unexpected at the time of the original installation, but it will always be found advantageous to make allowances for all possible future additions to the piping, so that little or no inconvenience may be felt by any one concerned.

Every plant has, to a certain extent, a system of piping peculiar to itself, and governed largely by the surrounding conditions, locality, and the nature of the work the plant has to perform. But in any case certain principles and requirements should be observed, if the plant is to attain any degree of success. There are many points to be considered in designing the piping for a steam plant. It should be remembered that piping is an expensive job at the best, and that while it is desirable to curtail the first cost, that is, install a job as cheaply as possible, it is also desirable to so design it as to give the best results for the longest period of time.

Piping may be classified as follows: The main steam pipe, running from the boiler or boilers to the engines; the exhaust pipes, running from the engines to the atmosphere or to the condenser, or to both; the system of drain pipes, which keep the main steam pipes free of condensation; the steam supply to the pumps and other auxiliary apparatus that may be contained in the plant; the feedpipes to the boilers; the piping of the steam-heating system, with its returns and methods of taking care of the condensation; and lastly, the various miscellaneous piping that is more or less contained in the average plant.

Each of these classes of piping has its own peculiar office in the plant, and requires to be designed to meet the requirements and conditions that are to control them.

Piping, for the most part, consists of wrought-iron welded pipes running in size from $\frac{1}{8}$ inch to 16 inches, the smaller sizes being "butt-welded," while the larger sizes are "lap-welded." The pipes of this class are connected together by screwed joints—a thread being cut at each end of each pipe and screwed into a fitting that has a tapped hole to suit the pipe. The joint is made tight by having the thread tapered, both on the pipe and in the fitting, and screwing them together sufficiently. It would, perhaps, be well to mention here that there is such a thing as screwing a pipe in *too* tight, that is, *straining* it, with the result that a leak will follow. A man working on this class of work very soon acquires a sense of touch that teaches him how tight to make up his joints without straining the threads, in order to gain the desired result—that of making a steam- or water-tight joint.

Cast-iron pipes are also used in steam plants for exhaust from the engines (where large units are in operation), and in some cases it is customary to have the main feedline, supplying the individual feedpipes to

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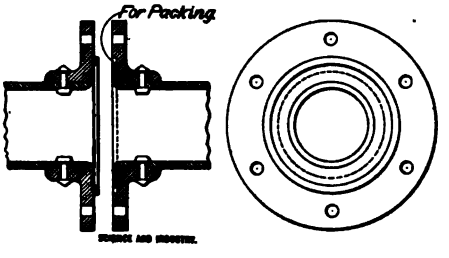
their respective boilers, made up of cast-iron pipes. These pipes are not threaded like the wrought-iron ones, but instead are joined together by flanges through which bolts pass, with nuts to tighten the joints. Sometimes these flanges are faced in the lathe to a plane surface, and when ready to unite the different lengths of pipe, a piece of some suitable material (of which there is plenty to select from in engineers' supply houses) is introduced between the "faced" flanges, which are drawn tightly together by the bolts.

Again, there is the "male and female" flange, used not only on cast-iron pipes, but also on wrought-iron. This joint, shown in the accompanying illustration applied to a wrought-iron pipe, has a circular groove cut in one flange and a corresponding projection left on the other, the section of each being rectangular; suitable material is inserted in the groove and pressed against by the projection, or *tongue*, as it might be called. The *kind of material* used between the flanges is altogether a matter of choice, and as there



are many good "packings," as they are called, to be obtained, it would be a waste of valuable space to enter into the details of the various kinds that may be used.

Cast-iron pipes are also used for the injection water system for the condensers of large engines, where there are two or more to be supplied, necessitating the use of a pipe of large diameter in order that a sufficient quantity of water may be delivered. These pipes are laid in a similar manner to the city water supply pipes that we occasionally get a glimpse at when a street is opened up to make repairs or lay new pipes.

Brass and copper piping is also used in certain places in the steam plant. In a well-designed plant, where symmetry has been considered, and things ornamental are desired, it is customary to have all of the small piping about the engines, such as the piping to which the indicator may be attached, that leading to the cylinders, and also the lubrication and oil-supply pipes, of nickelplated brass; in short, all the piping about the engine may be of brass, with the exception of the main steam pipe, and the exhaust pipe. Of course, brass pipes are more expensive than iron pipes, but they make a much neater job. Sometimes the feedpipes are made of brass; when kept bright and clean, they add greatly to the appearance of the boiler fronts. Of course, there are many plants in which the use of brass pipes is reduced to a minimum, and in some nothing but iron is used.

Copper pipes are occasionally used for feedpipes to the boilers; for the pipes connecting the water column, top and bottom, to the boiler; and for various gauges. In many steamships the principal pipes are made of copper, such as the main steam pipe, the feedpipes, the surface and bottom blow pipes, the gauge pipe, the suction pipes of all the pumps, the main injection, and the discharge from all the pumps. Copper pipes are made sufficiently strong to withstand the stress to which they may be subjected by the ordinary pressures in use. Being non-corrosive, they usually outlive the apparatus to which they are connected. Copper pipes most frequently have brass flanges attached, brass being, in general, more suitable. The pipe is extended through the flange sufficiently to permit of its being hammered over into a countersunk portion of the flange prepared for it. It is further made durable and tight by brazing the flange to the pipe. In large copper pipes and main steam pipes to the engine, the brass flange has an extension through which the pipe passes. In addition to the pipe being riveted over at the end and brazed, it is further strengthened by a row of rivets that fastens the pipe to the collar of the flange.

Each of these different pipes in use has its own peculiar advantages for the place and purpose designed. Care should be taken to make a proper selection when installing a new plant or refitting an old one, not counting so much on the first cost as on the possible—yes, probable—many future costs that will be incurred owing to improper material, and the introduction of hurried and slighted workmanship. In consequence of this comes a train of evils—parts of piping and fittings give out at a time when they are most required, involving a stopping of a part, or, perhaps, the whole of the plant. Then comes a hurried repair, when anything that is handy is pressed into service, with the expression "good enough" accompanying it.

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It sometimes happens that when such a repair as the above has been made, it is allowed to remain indefinitely, just as it was left; and while it may apparently be all right, yet there is no *reasonable* certainty about it; and if the cost of such repair—and subsequent ones—had been credited to the just cost of a properly designed and constructed system of piping in the plant, such a giving out would, in all probability, not have occurred. It is not only the cost of repairs themselves we have to consider, but the loss incidental to a shut down, that is sustained in other ways.

Not only should the piping in a steam plant be first class in every respect, because of the stresses it has to resist in the natural order of things, but also, and more particularly so, on account of the unnatural and unusual stresses that sometimes have to be resisted. There is no doubt that many an accident has been averted by an intelligent and careful designer, who did think of future possibilities and probabilities. The above has a general application, and now, before closing this portion of the subject, a few words about pipe fittings, connections, and attachments: The various fittings that are used in connection with the piping in a plant are known by individual names, and each one has a peculiar office to fill. There are valves of various kinds for the different purposes required; elbows, tees, couplings, unions (for there is a difference between a coupling and a union), reducing couplings, bushings, crosses, plugs, caps, and nipples; all these go to make up the pipe fittings in the steam plant.

CINDER CONCRETE

Maurice M. Sloan

COMPOSITION AND PROPERTIES—ITS VALUE AS A PROTECTOR FOR IRON AND STEEL AGAINST FIRE AND CORROSION

CINDER concrete, owing to its fire-resisting qualities, has long been recognized as a building material of considerable value; but much skepticism has prevailed regarding its use in conjunction with structural steel or iron, on account of the corrosive action of moist ashes or cinders in contact with that metal.

As a fireproofing, or, more properly, fire-resisting, material (for there is nothing that is actually fireproof) it can hardly be equaled, from the fact that its usual composition consists of the three extremely refractory materials: Portland cement, clean sharp sand, and steam ashes. Good Portland cement is manufactured at a temperature of from 2,600° to 3,000° F.; sand does not fuse much under 2,900°; and cinders are produced at temperatures ranging from 2,600° to 2,900°, measured on the same scale. From this it is evident that any of the three elements forming the concrete is sufficiently refractory to resist the highest temperature that is usually attained in conflagrations, which has been definitely ascertained to be not over 2,300° F.

It is not sufficient, however, that a material, in order to be adapted for fireproofing, should only be fire-resisting, but it must be fire- and water-resisting; that is, when it is heated to a high temperature and water played on it, such internal strains must not be created as will crack or disintegrate the material. All concretes composed of natural stone, such as granite, limestone, sandstone, and trap rock are not the best fireproofing materials, from the fact that these stones, when heated to about 2,000° F. and suddenly cooled, split from the sudden contraction, and consequently damage the homogeneousness of the concrete. The splitting of the stones is due to their compact structure, which does not permit of such rapid changes of form produced by the rapid lowering of the temperature. The aggregate of cinder concrete, that is the steam ashes, is more porous than stone, and adapts itself more readily to contraction by sudden cooling, being, as has been proved by extensive experiments, little subjected to disintegration under such conditions.

Cinder concrete is all the better for being laid loose, as when not tamped its porosity is retained, its weight much reduced, and its strength sufficient for all purposes in which it is likely to be employed. These several properties make it an excellent material for fireproof floor construction, as its porosity increases its natural refractory

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property; its lightness is invaluable from an economical point of view, as lighter beams, columns, and girders can be used throughout the building; its strength, when reenforced at the under surface with bars of iron, is astonishing, and is such that it will sustain the heaviest loads it will ever be called on to carry, and will even sustain the severe blows of suddenly applied loads without showing signs of distress.

Not only is cinder concrete capable of resisting high temperatures, but on account of its structure, when laid in freezing weather, it undergoes less deterioration than concrete made of stone, and work of this material put in place at low temperature has been found to suffer very little afterwards. Though the laying of any material in which the matrix is Portland cement should not be conducted when the thermometer is below 28° or 30° F., cinder concrete, in case of necessity, can be laid at a much lower temperature, especially if it is being used in floor construction where the centers supporting the material are of such open construction as to allow the surplus water to drain away before freezing can take place in the body of the concrete. The nature of the material allows this to be accomplished more rapidly than would occur with other concretes.

Any one experienced in construction work has observed the rapid and complete destruction of iron or steel when in contact with damp ashes or cinders, and has, no doubt, noticed that even cast-iron pipes running through cinder banks oxidize rapidly, and in a short time are unfit for use. Hence it is only natural that on this account cinders as aggregate for concrete should be looked upon with some disfavor by those who contemplate using that material in conjunction with steel or iron.

The active agents producing corrosion are three: water, carbonic acid, and sulphuric acid. The water and carbonic acid occur in the atmosphere, and if allowed to come in contact with the bare metal will cause corrosion. Where the metal is embedded in the concrete, however, there is little chance of this occurring, and no more opportunity is offered by the use of cinder concrete than in others in which the principal ingredient is stone, the cement in any case being the protective material.

That cement will protect iron and steel from corrosion indefinitely, is well known from observation and experiments, and if it protects the metal against the action of moisture and carbonic acid, it is reasonable to suppose that, if the cinders are embedded in a sufficient matrix of cement mortar, there will be no action on the metal due to the sulphuric acid, or to sulphur, as sulphide, in the cinders. Sufficient matrix, in order to completely protect bare iron or steel, can only be had in complete cinder concrete, which is obtained by the proportions of 1 of sand, 2.75 of cement, and 4.75 of cinder. Such a concrete is not nearly so good a fire- and water-resisting material as the usual mixture of 1, 2, and 5, and is not as practicable, for it is heavier, and is not in accordance with the building ordinances, as usually framed in the principal cities.

Though the usual concrete in the proportion of 1, 2, and 5 will not entirely protect bare iron or steel, and some oxidation will take place more or less rapidly, depending on the absence or presence of moisture, it is hardly likely that the corrosion will be serious with the iron or steel used in the ordinarily dry atmosphere between the floors of a building. The concrete, however, contains considerable moisture when it is first laid, and an initial corrosion is likely to take place before the concrete has dried out. In order to avoid this initial corrosion, which is serious, for when it once starts it is liable to continue, owing to chemical action and reaction, the iron or steel should be painted with some good paint, preferably one free from oils that are likely to be affected by acids and alkalies. Some paint of the asphaltum variety would probably be best.

Since meager concrete in the proportion of 1, 2, and 5 fails to entirely protect bare iron or steel, it would be good practice, where possible, to cover the metal with a thin coat or layer of cement mortar of 1 part Portland cement and 2.75 parts of sand, and then follow with the concrete. If this is done, the concrete will not come in contact with the metal, and the steel or iron will be fully protected from corrosion, which, though slight and probably locally confined, is likely to be instituted from the several causes previously cited.

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FUNDAMENTAL IDEAS OF ALTERNATING CURRENTS*

Dugald C. Jackson

A DEEPLY rooted belief seems to have been cultivated in the minds of many that phenomena connected with the flow of continuous electric currents and of alternating electric currents are as widely separated as are the extremes of the diameter of eternity. This popular idea, however, is totally erroneous; the principles which relate to the flow of direct and alternating currents and which are applied to the design and construction of machines and circuits are one and the same. The desire to have this truth expounded at the present meeting seems to have taken full possession of President Doherty, and he has persuaded me into making an effort at exposition. Mr. Doherty also desired that some direct applications of theory to the operation of alternating-current machinery should be included in the paper; but these are not included, on account of my feeling that any addition to an antecedent extended paper would unduly burden the time of the Association.

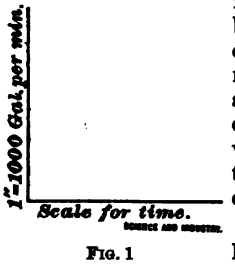

FIG. 1

Without further explanation or apology for this paper, I will say that it purports to be simply a straightforward statement of the elementary electric and magnetic principles which relate to the flow of alternating currents. To the majority of those interested in the subject, the paper contains no new information; those to whom it is new, will perhaps not be interested. I have even been careful, in choosing analogies, to select as far as possible those heretofore used in electrical literature, and have then utilized them in the most straightforward manner for illustrating electrical phenomena.

When Oersted, in 1820, made known his signal discovery that an electric current exerts a magnetic influence in the space around it, the foundation was begun for our knowledge of the laws of the flow of alternating currents. Within a dozen or fifteen years thereafter much knowledge of the magnetic effect of the electric current had been thrashed out experimentally by men like Ampere, Arago, Faraday, and Henry. And the last two laid the finishing stone on

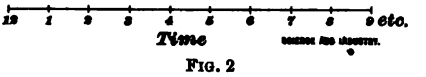

FIG. 2

the foundation by searching out and making known the laws of electromagnetic induction.

The apparent flow of electric current may be likened to the flow of a fluid, and it may be either *continuous*, *pulsating*, or *alternating*.

1. The first is analogous to the flow of an unbranched river through its channel, in a season of uniform flow. The water flows continuously onward without pause or hesitation. The velocity of the stream is affected by the character of the banks and the contour of the country traversed; but the onward motion of the volume of water never ceases, and the quantity of water flowing past any cross-section of the channel is always the same, though its width, depth, and velocity may change with the character of the channel. We may represent the flow in a graphical manner is this way: Suppose distances measured on the vertical from a zero or horizontal line represent the quantity of water which each minute flows past some point along the river. Then a vertical line 1 inch long (see Fig. 1), we will say, means that 1,000 gallons of water pass the point in

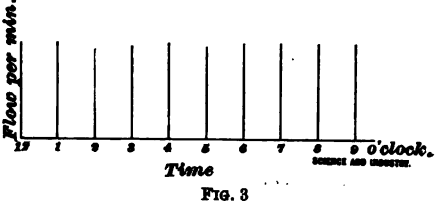

FIG. 3

every minute. Now suppose a number of measurements are made through 24 hours, and the clock times when the measurements are taken are recorded. Then we have a number of vertical lines, each 1 inch long for every 1,000 gallons per minute, to represent the amount of water flowing at each

* Paper read before the Northwestern Electrical Association, by Dugald C. Jackson, Professor of Electrical Engineering, University of Wisconsin.

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instant through the day and night. We can now extend our chart and divide our horizontal line of zero quantity into parts each representing 1 hour, as in Fig. 2. And at each of the clock times set down we may

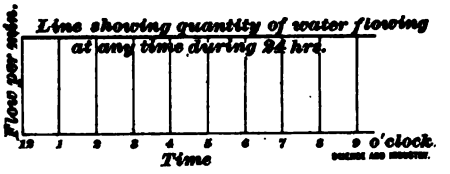

FIG. 4

erect the vertical, which has a length corresponding to the quantity of water flowing. This river is continuous in its flow, and all the verticals are therefore of equal height, as in Fig. 3.

We may take our observations of flow as frequently as we choose and erect the corresponding verticals at the points corresponding to the clock times of the observations. Finally, by drawing a line through the tops of the verticals we have a chart which shows by the vertical height of this line the rate of flow at any time during the 24 hours (Fig. 4).

In the case we are considering (that of continuous flow) the line drawn through the ends of the verticals is a horizontal line, that is, the chart shows that the flow of the water is uniform.

2. A *pulsating* current may be likened to the flow of arterial blood. With each heart beat the blood rushes forward and then slackens in velocity, and then again rushes forward as the heart beats again. Our chart, which shows the quantity of blood flowing through the artery at each instant, is in this case composed of a wavy line which never crosses the zero line, as is shown in Fig. 5.

The horizontal scale now, instead of being made in hours, may be more conveniently made in seconds or fractions of a second, since the blood pulsations come many times

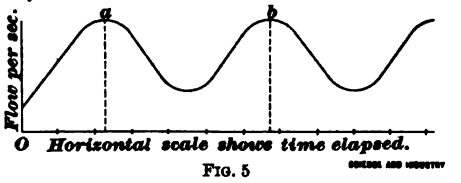

FIG. 5

per minute; and the vertical scale may be made to represent a flow in fractions of a fluid ounce per second instead of gallons per minute, because of the limited amount of blood that flows in an artery.

The vertical height of the wavy line in the chart above the horizontal scale line still shows the amount of blood flowing at each instant, corresponding to the times read on the horizontal scale. The *frequency* of the heart beats is the number of pulsations made per minute, which is not far from 70 in the average human adult, and the duration, or *period*, of the pulsations is therefore not far from $\frac{1}{70}$ of a minute. The period is represented on the chart by the time elapsed between two like points, as the two points of greatest flow, *a* and *b*.

3. Finally, the *alternating* current may be likened to the flow of water in a narrow tideway. As the tide rises, the water rushes up the channel until near high tide, when the flow gradually ceases, turns, and then with increasing flow the water rushes down the channel until near low tide, when its outward flow gradually ceases, turns, and with increasing flow the water begins to rush up the channel again. The action is repeated

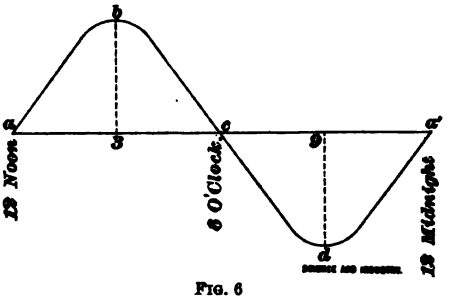

FIG. 6

again and again as the days pass by. The *period* of the complete action, or cycle, i. e., from low tide to high tide and back again, is a little over 12 hours, and the *frequency* is therefore nearly two periods per day. We can represent this *alternating flow*, or *current*, also by a chart, as shown in Fig. 6.

Assuming the period to be exactly twelve hours (which is near enough for the analogy), and taking a day in which low tide occurs at 12 o'clock noon, then, at this time (12 o'clock noon) no flow is occurring; a little later the flow is up the channel as the tide rises, and the rate of flow increases for a time. This portion of the tidal period is represented by the portion of the curve between *a* and *b* in Fig. 6. It is to be borne in mind that the vertical height of the curve shows the amount of water flowing per minute at the instant considered (not the height of the water). The flow continues up the channel for a further length of time, but at a decreasing rate, until high tide is

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reached at 6 P. M. Then, for an instant, there is no flow of the water. In representing this, our curve, dropping down from b, crosses the line of zero flow at the point

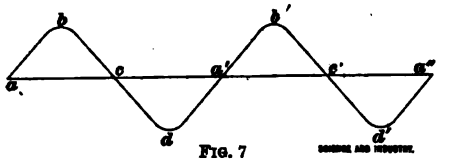

FIG. 7

marked c, which corresponds to the instant of no flow at the time of high tide.

Half a tidal period has now been completed; the tide has reached its flood and begins to fall, and the flow therefore reverses and runs outwards. Since the flow inwards, or up the channel, is shown on the chart by a vertical distance above the line of zero flow, it is natural to represent the outward flow by a vertical distance below the line. After the turn of the tide the amount of flow increases for a time up to a maximum and then decreases as the low tide is approached. This is represented by the curve from c through d to a'. At the latter point, low tide has been reached and an entire cycle of the tide has been completed, and is represented on the chart. The chart might be continued indefinitely, representing the cycles of successive periods if desired, as in Fig. 7.

It is well known that the character of the tidal flow is greatly affected by the character of the channel. For instance, in a narrow, crooked channel, the phase of the flow is retarded as one proceeds along its length, through the buffeting action of the banks; and the times of high and low tides, when

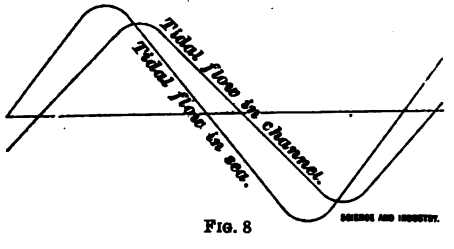

FIG. 8

the flow in the channel is zero, may not correspond with the times of similar tidal phases in some other channel or in the open sea. In this case we may say that the tide in one channel *differs in phase* from that in the other or that in the sea, and a chart may be drawn to represent the respective cycles of sea and channel tides at certain selected points, as in Fig. 8. In this figure the tidal cycle in the channel is shown to be *retarded, or behind the tidal cycle of the sea.*

Alternating currents of electricity, flowing in branch circuits, may be at different phases, and they may be represented on a chart entirely similar to that of Fig. 8. The currents are said to be *out of phase*, and may be said to be in advance of or behind each other, depending upon which is looked upon as the datum for comparison; exactly, for instance, as we may with equal propriety and the same meaning,

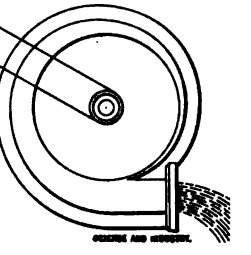
FIG. 9

say either that the channel tide is behind the tide of the open sea, or that the tide of the open sea is in advance of the channel tide.

To recapitulate, the electric current may be continuous, pulsating, or alternating. The first is likened to a continuous flow

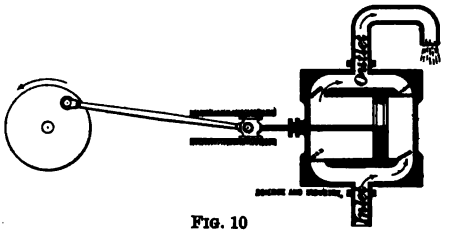

FIG. 10

of a river, the second to the pulsating flow of arterial blood, and the third to the alternating flow of water in a tideway. Continuous and pulsating currents, that is, currents which flow continuously in one direction, are called "direct currents."

We may give another set of analogies, so as to show relations still more clearly.

1. A continuous current is like the uniform current of water set in motion by

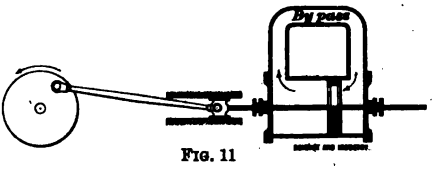

FIG. 11

means of a centrifugal pump operated at a constant speed (Fig. 9).

2. A pulsating current is like the current of water set in motion by a piston pump. As the piston moves forward in the water cylinder, the water therein is forced to flow

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through the delivery pipe; when the piston reaches the end of its stroke the flow slackens or ceases; and as the piston returns on the stroke the flow again proceeds, as before, through the delivery pipe and slackens as the piston reaches its initial position (Fig. 10). This is repeated as the stroke is repeated, and the action causes a succession of impulses to the water, with intervening pauses or slackening of the current.

3. An alternating current is like the current of water which would be set up in case the delivery and suction pipes of the piston pump were connected directly together and the valves removed. Now, as the piston moves back and forth, the water flows unceasingly back and forth alternately from one end of the cylinder to the other as long as the pump is operated (Fig. 11).

Fig. 11 shows clearly that a complete cycle of flow is produced with each revolution of the pump driving shaft, that is, with each 360 degrees of angular motion of the shaft. We may, therefore, for the sake of convenience, divide the horizontal zero line, or

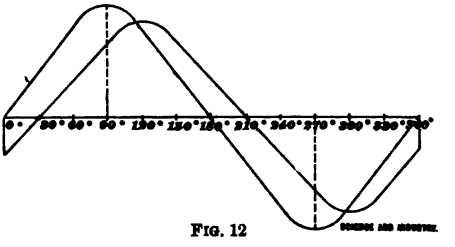

FIG. 12

axis, in our charts into 360 parts for each "period" of the flow, and call the parts "degrees" instead of fractions of time. This is illustrated in Fig. 12, which shows two alternating currents of different phases. We may speak of these as having 30 degrees difference of phase, or they are 30 degrees apart, since they cross the horizontal axis at points which are 30 divisions, or *degrees*, apart.

The alternating curves which are shown in the figures are all smooth curves, but actual waves of alternating current and pressure are usually more or less irregular in outline, and sometimes they are very irregular; but successive loops are normally similar. Two alternating-current curves, the outlines of which were determined by experimental means, are shown in Figs. 13 and 14.

It is also a fact that alternating-current curves do not have the same shapes as the waves of pressure which are applied to the circuits to produce the currents, whenever any iron is magnetized by the currents—which is almost always. The curve in Fig. 13 is a curve of current which was set up by a quite flat-topped, steep-sided pressure wave, while the curve of Fig. 14 was set up by a smooth pressure wave with a form quite like a sine curve. Changing the iron or other conditions of the circuit would produce changes in these current curves, though the pressure curves remained unchanged.

If a heavy block is suspended so that it is perfectly free to move, and then is struck a sharp blow, for an instant it offers a force which opposes the force of the blow almost as though the block were rigidly fastened. This opposing force is well known to be caused by the *inertia* of the block. Inertia sets up a force which tends to violently oppose any sudden change in the motion of a body, and when the suspended block is started swinging, it may strike a considerable blow upon its own account when met by an obstacle.

When an electromotive force is introduced into an electric circuit, the circuit, by a kind of electromagnetic inertia, opposes the immediate flow of the current (very much as the inertia of the suspended block opposes the force of a blow before the block moves), and the rise of the current in the circuit is retarded. If the circuit is severed or broken while current is flowing, the electromagnetic inertia makes an effort to uphold the current (as the swinging block is difficult to stop), and an electric spark appears as its evidence in the gap between the severed ends of the wire.

Faraday (whose name is almost a household word on account of his discoveries in natural philosophy, and especially in electricity and magnetism) was well acquainted with this retarding effect as early as 1835, and describes it in his "Experimental Researches." He says: "Returning to the phenomena in question, the first thought that arises in the mind is that the electricity circulates with something like *momentum* or *inertia* in the wire, and that thus a long wire produces effects at the instant the current is stopped, which a short wire cannot produce. Such an explanation is, however, at once set aside by the fact that the same length of wire produces the effects in very different degrees, according as it is simply extended, or made into a helix, or forms the circuit of an electromagnet." He then shows that the apparent inertia is due to the magnetic effect

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of the current. For instance, he says: "Further investigation led me to perceive the inaccuracy of my first notions, and ended in identifying these effects with the phenomena of induction which I had been fortunate enough to develop in the first series of these experimental researches."

Faraday further speaks of this as a *retardation* of the electric current in the circuit, and ascribes the effect to the "induction of the current on itself," or "self-induction" of the circuit. The phenomena of electromagnetic induction were studied about 1850 (15 years after Faraday's experiments) by Sir William Thomson (now Lord Kelvin), Helmholtz, and other scientists, who brought to their aid the powerful resources of mathematics, and their work was canvassed and discussed by Maxwell in his book on electricity and magnetism, who shows that the effect of self-induction is truly the result of *electromagnetic momentum, or inertia.*

The retardation of the current by electromagnetic inertia was shown by Faraday to occur *when the current is changing in value,* and it therefore exercises a marked influence on the *ever-changing alternating current.* Faraday showed that the value of the changing current was retarded, or lagged behind the value which it might be expected to attain, and which a uniform current under the same conditions would attain. We therefore know that an alternating current will lag behind the phase of the alternating electromotive force which causes it to flow, if there is self-induction in the circuit. The amount of the lag depends upon the electromagnetic character of the circuit. Thus, a straight wire causes less *retardation,* or lag, than the same

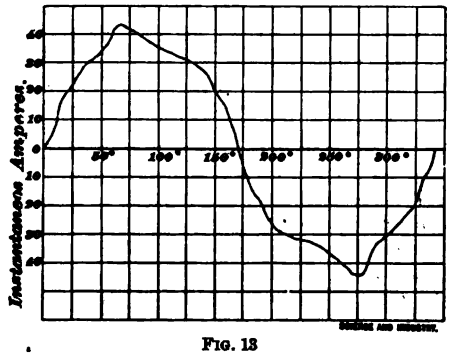

FIG. 13

wire wound in a helix, because the helix increases the magnetic effect. Inserting an iron core in the helix may increase the retardation enormously, since the presence of the iron again increases the magnetic effect. Faraday said: "If an electromagnet be employed, the effect will be still more highly exalted," as compared with the effect of the plain coil or helix of wire.

Faraday's experiments were mostly carried on with varying or pulsating currents,

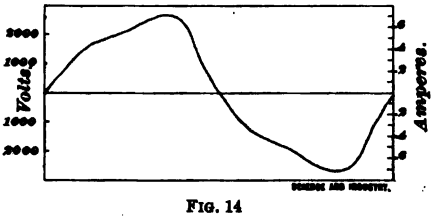

FIG. 14

but later investigators took hold of alternating currents and much attention was given to the laws of flow of alternating currents at the time alternating-current dynamos became known.

We all have at our fingers' ends the well known ratio generally called Ohm's law, in which it is asserted that a continuous current is equal to the electrical pressure upon a circuit divided by the electrical resistance of that circuit. This so-called law is nothing more than a special statement of a condition which may be recognized as universally applicable to the phenomena of nature. The general statement may be put thus: The result of an effort is equal to that effort divided by the opposing resistance. Thus, for instance, if we stretch an elastic material, the amount of stretch will depend upon the ratio of the pull to the elastic resistance of the material; if we try to push a heavy block along the floor, the velocity of the block will depend upon the ratio of the force exerted to the frictional resistance opposing the motion; and so we could go on indefinitely illustrating the general applicability in nature of this statement that the result is dependent upon the ratio: effort divided by resistance.

We then have for the flow of continuous currents the rule that current flowing ("result") is equal to pressure ("effort") divided by the opposition to the current flow ("resistance"); but in the case of continuous currents there is no opposition to the flow of the current except electrical resistance (that is, the resistance which is determined by the nature, temperature, and dimensions of the conductor), whence we have Ohm's law for the flow of continuous currents.

The fundamental law of the flow of alternating currents follows directly from what

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has gone before. The alternating current flowing in a circuit is equal to the pressure divided by the opposition to the flow of the current. In this case the opposition is made up of two parts, one the electrical resistance spoken of above, and the other the opposition due to electromagnetic inertia. The latter effect is a sort of inductive resistance and is commonly called *reactance*. The total opposition to the flow of alternating currents which is made up of these two components (resistance and reactance) is called *impedance*, and it is numerically equal to the square root of the sum of the squares of the electrical resistance and the inductive resistance, or reactance. These three factors, therefore, bear the same relation to each other as the three sides of a right-angled triangle in which the hypotenuse has a length equal to the impedance, and the base and altitude are respectively equal to the electrical resistance and inductive resistance (Fig. 15).

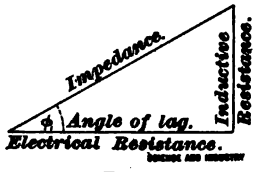

FIG. 15

The fundamental laws of flow of alternating currents may be briefly stated thus:

1. The current flowing in a circuit is equal to the alternating electromotive force divided by a quantity called the *impedance*, or apparent resistance. This impedance is equal to the square root of the sum of the square of the electrical resistance and the square of the inductive resistance.

2. The alternating current lags behind the alternating electromotive force applied to a circuit containing inductive resistance by a certain angle (as illustrated in the chart called Fig. 12). The trigonometrical tangent of this angle is equal to the inductive resistance of the circuit divided by its electrical resistance.

The electrical resistance of a wire composing a circuit depends, as is well known, upon the material and temperature of the wire, its length and its cross-section; and it is not affected by the flow of current, provided the temperature is not affected thereby. The inductive resistance is dependent upon the self-induction (i. e., the electromagnetic condition of the wire) and the frequency of the alternating current. The effect of the self-induction is to retard the rise and fall of the current so that it attains its maximum later than the maximum of the alternating pressure which sets it up; and it also increases the apparent resistance to the flow of the alternating current in the circuit. Thus, if the curve No. 1 in Fig. 16 is taken to represent the alternating current which flows in a circuit supposed to contain no self-induction, then No. 2 can be taken to represent the current which flows when there is self-induction. No. 2 is retarded with respect to No. 1, and reaches a smaller maximum value.

These laws can be put into very simple mathematical form:

Alternating current

$$= \frac{\text{alternating electromotive force}}{\sqrt{(\text{electrical resistance})^2 + (\text{inductive resistance})^2}}.$$

Tangent of angle of lag

$$= \frac{\text{inductive resistance}}{\text{electrical resistance}}.$$

It is usual, for brevity, to use the letter C to represent electric current, the letter E to represent electromotive force, the letter R to represent electrical resistance, and the Greek letter ϕ to represent the angle of lag. Inductive resistance is equal to a constant (equal to twice 3.1416+) times the frequency of the alternating current times the self-induction coefficient for the circuit. The letter L is usually used to represent the latter coefficient; the letter f is often used to represent the frequency of the current; and the constant 3.1416+, which enters into a large number of physical equations, is usually represented by the Greek letter π. Inductive resistance is therefore represented by the collection of letters $2\,\pi\,f\,L$.

Using these symbols, we have our laws of flow represented in the manner that they would usually appear in textbooks or published articles. Or,

$$C = \frac{E}{\sqrt{R^2 + (2\,\pi\,f\,L)^2}};$$

$$\tan\phi = \frac{2\,\pi\,f\,L}{R}.$$

In Fig. 16, the distance from a to b measured in degrees (it being remembered that each degree is represented by a length equal to $\frac{1}{360}$ part of the distance, $a\,a'$ representing the length of one period) is the angle of lag ϕ. The angle of lag ϕ is shown in Fig. 15.

I will use numerical examples to illustrate the way in which the laws apply. Let us assume that we have a circuit with $\frac{1}{10}$ of a unit, or ohm, of resistance, and $\frac{1}{1000}$ of a unit of self-induction. What will be the angle of lag when the frequency is 60 periods per second (this is a common commercial

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frequency)? The formula representing the current lag becomes

$$\tan \phi = \frac{2 \pi f L}{R}$$

$$= \frac{2 \times 3\ 1416 \times 60 \times .001}{.4} = .943-.$$

The angle corresponding to a tangent of .943— is nearly 43⅓ degrees, and the value of the angle ϕ is therefore nearly 43⅓ degrees.

Now suppose that we increase the number of turns of the wire so as to increase the inductive resistance to double the value assumed above, and carefully avoid changing any other feature. Then $\tan \phi$ becomes equal to twice its former value, or 1.886—, and ϕ is a little over 65 degrees. Exactly the same result would have been brought about by using larger wire in the circuit, so that the electrical resistance was reduced to one-half its former value without changing anything else, or by altering both the inductive resistance and electrical resistance so that the ratio $\frac{2 \pi f L}{R}$ is doubled.

It is clear, then, that the alternating current in a circuit may be given any desired lag or retardation, at least up to nearly 90 degrees, by merely adjusting the electrical condition of the circuit so as to properly fix the ratio of inductive resistance to electrical resistance. This may be done by changing the character of the circuits or by introducing into the circuits what are called variable resistance coils, or variable self-induction coils, or it may be done by changing the frequency of the alternating current flowing in the circuit.

When the electric current flows through a circuit the power that is absorbed in the circuit at every instant of time is equal to the product of the pressure at that particular instant and the current flowing at the same instant. In direct-current circuits the pressure and current are virtually constant; consequently, the power is continually the same and without changes from instant to instant, however long the current continues to flow, provided the indications of voltmeter and amperemeter remain unchanged. The indications of these instruments therefore show the average current flowing and the average pressure applied to a circuit so that their product gives the average power, and we say that power is equal to current times pressure, or, what comes to the same thing, power is equal to current squared times resistance.

The same fundamental principle applies in the alternating-current circuit; that is, the power expended at every instant is equal to the corresponding product of the instantaneous current and the instantaneous pressure. Our amperemeter and voltmeter, however, do not indicate these instantaneous values, and it is only when the circuit contains no self-induction to cause a lag of current through the effects of electromagnetic inertia that power is equal to the

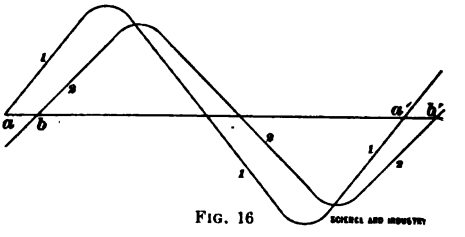

FIG. 16

product of the alternating current and the alternating pressure indicated by the instruments. When the current is displaced with respect to pressure (that is, it is caused, for instance, to have a lag on account of the effect of electromagnetic inertia), the average of the instantaneous values of the power throughout any complete cycle in the alternating-current circuit is always less than the product of the current and pressure read from the amperemeter and voltmeter. This product of amperes times volts is generally called the apparent power, or volt-amperes in the circuit, and the ratio of the true power to the volt-amperes is called the *power factor*. When the waves of current and pressure are exact sinusoids (sine curves), this power factor is numerically equal to the trigonometrical cosine of the angle by which the current lags behind the pressure. But the condition of exact sinusoids for both current and pressure can be said to be never met with in practice, and indeed it is seldom that either of the curves are exact sinusoids, though pressure waves are not uncommonly made up of curves that approximate quite closely to that form.

We must therefore consider the power factor as simply the ratio between the true power and volt-amperes in the alternating-current circuit, and we may say that it is equal to the cosine of the apparent angle of lag in the circuit.

Power may be measured by a wattmeter. This is an instrument which indicates the average of the product of instantaneous currents and pressures in the alternating-current circuit. In the case of indicating wattmeters we have a simple pointer which plays over

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a scale in a manner similar to the arrangement shown by amperemeters and voltmeters. In the case of recording wattmeters the armature of the instrument is usually caused to rotate continuously when power is being absorbed by the circuit to which it is attached, and a record is made of its rate of rotation, or of the number of its rotations. The rate of rotation in this case is proportional to the average of the products of instantaneous currents and pressures. In the indicating wattmeter the rotary effort is balanced by means of springs, and the deflection of the needle is thereby caused to be proportional to the average of the product of instantaneous currents and pressures.

The power factor of a single-phase circuit may always be found by measuring the power by a wattmeter and the volt-amperes by means of an amperemeter and a voltmeter, and taking the ratio of watts to volt-amperes.

DRINKING WATER AND THE PUBLIC HEALTH

G. H. Dimpfel, Ph. D.

SOURCES OF SUPPLY—ADVANTAGES AND DISADVANTAGES OF EACH—ZYMOTIC DISEASES—THE GERM THEORY—WATER SUITABLE FOR DOMESTIC USE

THE question of an adequate supply of good drinking water has been one of vital importance in our growing cities and towns, and a great deal of consideration has been given to it by every public-spirited person. The sanitary conditions of the water supply of the cities are discussed by the public as well as by newspapers, and opinions are often heard and read that are so absurd that a short consideration of this question seems in the right place.

Up to a few years ago little was known of the bacteriology of water, but as this science has advanced so much of late, it is now generally conceded that a chemical analysis is not sufficient to establish the usefulness of a water supply, but that the results of such an analysis should be supported by a bacteriological examination. While one cannot but feel that, in their enthusiasm over the great triumphs of bacteriology, the people at large have gone slightly "bacteria-mad" and are apt to expect more than is warranted by the means and information at present available, yet the fact remains that the hostility heretofore manifested by the supporters of the allied sciences has now entirely disappeared, and chemistry and bacteriology stand on an equal footing as a necessary means to the thorough investigation of a water supply.

In the discussion of the water supply for towns and cities, the first question that arises is: From where do we get our water?

The sources of water supply are varied, and the general supply for towns and households may be best classified as follows: rainwater; surface water, including lakes and streams; ground water, including shallow wells; deep-seated water, including deep wells, Artesian wells, and springs.

Each of these classes has its advantages and disadvantages when used for drinking, culinary, or technical purposes. It is not the intention of this article to consider these, but to state in a general way the connection that exists, or is supposed to exist, between drinking water and the public health, as this is the question that interests the public most, and the one that is not always intelligently discussed in our daily press.

A water that contains a considerable amount of dissolved substance—one that could be properly denominated as a "mineral water"—would scarcely be chosen for a public water supply, and is hardly ever used as a daily beverage, except for the sake of its real or fancied therapeutical effect, although a small amount of mineral matter doubtless is an advantage so far as taste and healthfulness are concerned. The presence of those substances that usually exist in solution in natural waters must, however, not be regarded as essential, because experience on shipboard has taught us that distilled water, after being aerated, is perfectly wholesome. It appears, then, that distilled water, soft surface water, and moderately hard spring and well water may be considered perfectly wholesome, and may be consumed by persons without bodily inconvenience, although it is certainly true that a person who is in the habit of drinking soft

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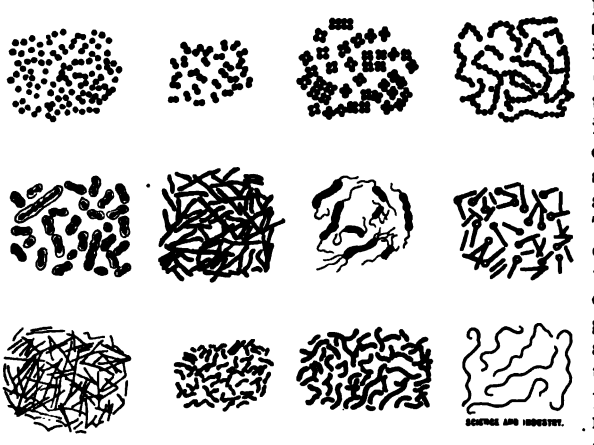
water generally experiences some temporary derangement of the digestive organs on beginning to use hard water, and vice versa. It is generally contended that the human body requires salts of calcium, etc. for its maintenance, and that these compounds are furnished in an assimilable form in water; consequently, a somewhat hard water offers an advantage for a town supply. Attempts have been made to bring forward statistics in the support of this view, by comparing the death rate of various towns with the hardness of the water supplied. These alleged proofs will, however, hardly stand close scrutiny, as the death rate of a town depends on too many factors to be used as a justified argument in this connection, although it must be admitted that water whose hardness is due to either magnesium salts or calcium sulphate, is not very well suited for drinking purposes, and it certainly acts injuriously on the health of most persons.



Waters, especially surface waters, containing considerable quantities of vegetable matter, must be, as a rule, considered unwholesome. They frequently cause diarrhea and diseases of a similar character, as well as malarial and other fevers. The mere presence of vegetable matter, however, does not seem sufficient to produce these diseases, as experience has shown quite frequently that water which is highly colored by vegetable matter has been used by persons for many years without any ill effect whatever. While some waters are, in what may be called a natural condition, unwholesome and produce disease or sickness under certain conditions, the attention of the water expert is directed principally to those waters that are polluted by the close habitation of man, by waste material of factories, and by the sewage of towns; and it is now generally acknowledged that such water may be, and frequently is, the cause of certain specific diseases.

Before discussing this question directly, it is important to first obtain a general idea of the prevailing view with reference to the so-called "zymotic diseases," and to understand what is meant by the "germ theory." It frequently happens that an apparently clear water, when allowed to stand exposed to the influence of air for some time, becomes turbid or cloudy, or a film forms on the surface of the liquid and on the walls of the vessel containing it. This turbidness is indirectly due to the contamination of the water with organic vegetable or animal matter, and, as a microscopical examination shows, is caused by the presence of countless minute organisms of various forms and shapes—some globular, some rod-like—which prove to be capable of self-propagation and also possess the property of motion. Similar organisms have been found in the dust that floats in the atmosphere, and consequently occur in rain water (particularly in that which falls in the beginning of a shower), in surface water, and elsewhere. They are especially abundant where there is decomposing organic matter, and appear to take an active part in the promotion or production of the chemical changes that take place. Organisms of the same or of similar character have also been found in the blood and in the substances of various organs of man and the lower animals afflicted with certain diseases, and their connection with these diseases appears to be a causal one.

The micro organisms with which we are at present concerned belong to the vegetable kingdom; they are related to the fungi and Algæ, and are scientifically known as Schizomycetes. They are, as has been previously stated, very minute, and a powerful microscope and considerable skill in observation are necessary requirements in their study. Their lives have been made the object of careful and patient observation, and it has been found that they not alone propagate by fission, but also by the formation of "spores," or permanent "germs." With

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reference to specific distinctions between these organisms, scientists do not exactly agree, while some observers prefer to restrict the number of specimens and assign the differences in appearance and action to differences in the attendant conditions; others assert there are many species, as distinct as those observed in higher organisms, and that the observed differences are essential, and the inability in all cases to satisfactorily recognize specific characters is chiefly due to inadequate means of observation. Be that as it may, for general purposes of study, at any rate, the various observed forms may be classified in genera and species. Referring to a few terms of somewhat frequent and common occurrence, the *micrococci* are globular or oval, the *bacilli* are rod-like, the *vibriones* are sinuous, etc. The illustration shows some specimens of common bacteria that are supposed to cause such diseases as pneumonia, tuberculosis, diphtheria, cholera, and lockjaw.

The modern "germ theory" of disease is that a considerable number of various diseases are due to the presence and propagation in the human or animal system of these minute organisms, which are generally known as "bacteria," a term that also includes those organisms which are assumed or known to be harmless. Some of the diseases that are caused by these organisms are tuberculosis, malarial fever, typhus and typhoid, relapsing fever, splenic fever, cholera, diphtheria, and yellow fever. The connection of the bacteria with many diseases has been clearly established, as, for instance, in the case of splenic fever. In this disease, the blood and various organs, especially the spleen, contain a multitude of one of these organisms that has been termed *bacillus anthracis*. These organisms have been transplanted from the infected organs, and have been cultivated in appropriate fluids where the development and formation of spores could be observed, and from the spores thus cultivated the specific disease has been reproduced in living animals. It has been found that the organisms, as observed in the blood, usually die rapidly, that is, within a few days, but that the spores retain their vitality for four years and longer.

If, from such data, we now consider the theory proved that these organisms are present in the bodies of persons afflicted with certain diseases, and are the cause of such diseases, and that these organisms can exist, at least in certain stages of development, outside of the human body, and retain their vitality for long periods, we have to face the all-important question: How do they find their way into the system of healthy persons? The two most obvious of the possible carriers of these little enemies of health and comfort are the air we breathe and the water we drink. We certainly find no serious difficulty in assuming that emanations of sick persons may find their way into the atmosphere; moreover, the dejections of the sick and the water with which their persons and clothes have been cleansed, may evaporate in the air, or reach wells and other sources of drinking water. Of these two sources, the air is certainly the most probable, not alone because we take much more air in the lungs than water in the stomach, but also because the lungs afford a much easier channel to reach the blood than the stomach; in fact, for a long time doubt has existed whether any organism entering the stomach could be harmful, and some scientists still maintain the belief that these organisms entering the stomach are either destroyed or rendered harmless, and that water, however contaminated with these organisms, cannot be considered as a means of conveying disease germs.

Of the diseases that are supposed to be caused by micro organisms—to be propagated by germs—those that have been most positively ascribed to the use of impure drinking water are cholera and typhoid fever. With reference, however, even to these diseases, there has been much discussion and controversy between the opponents and adherents of the "drinking-water theory," since 1848, when Snow, Budel, and a few other English physicians ascribed the spread of the cholera, then raging in London, to the use of drinking water that had been fouled by the dejections of persons stricken with this disease, and thus first advanced the theory that the disease was brought to the human body by contaminated water.

The most earnest advocates of the drinking-water theory, which most of our physicians are, must, however, admit that the theory has not yet been proved, at least not in the sense in which a mathematical proposition may be proved, and it cannot be positively stated that drinking water is the only means by which zymotic diseases may be propagated; the "coincidences," however, if we do not choose to accept the word "proofs" for the sake of argument, are most remarkable, and every year adds largely to their number. Many instances might be cited where a number of persons, using the same well or other source of water supply,

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have become victims of one of the zymotic diseases, which was not prevalent in the neighborhood, and where the closing of the suspected water supply at once effectually put a stop to the further spread of the disease; there are also instances where people have assembled in numbers on account of some celebration, and sickness has followed in the case of a large proportion of those who had used a certain water supply, while others were not affected; lately there have been many cases where sickness has broken out among a number of families obtaining their milk from the same source, and searching investigations brought forth the fact that contaminated water was used in the dairy. These investigations aroused, of course, more or less criticism from the side of the opponents of the theory. The most weighty criticism urged against the acceptance of the theory that regards contaminated water as the source of disease is that these investigations have been wholly one-sided, and that sufficient attention has not been paid to other features of the circumstances and surroundings that might, with equal likelihood, be factors in the production and propagation of the disease. This criticism is certainly just in many cases, but even if we drop all those cases in which investigation and observation have been manifestly imperfect, there will remain enough cases to make the connection between certain water supplies and certain epidemics of disease extremely probable.

Although this is a matter that, in our present state of science, has apparently not been finally proved, the duty of those that have to advise and decide in matters relating to water supply appears to be plain; it is to err on the side of safety to admit the hypothesis that specific diseases may be conveyed by water, and to guard zealously the sources of domestic and public supply from the possibility of contamination by the dejection of persons sick with zymotic diseases, and by excremental matter in general.

All that has been said referred to the contamination of water by excremental matter from persons known to be sick with contagious diseases. Any contamination with excremental matter should be strictly avoided, as there is strong evidence that, under certain conditions, the discharges of healthy persons and animal matter in general may give rise to disease, although the exact conditions under which such matter becomes dangerous to health or life is not yet known. It is difficult to believe that in ordinary excremental matter there is any specific poison, but as there is abundant circumstantial evidence to show that disease does, at times, follow the use of water that has been polluted in this way, we are forced to assume either that the organic matter undergoes change, and, in a certain more or less advanced stage of decomposition, can produce sickness, or is accompanied by something not yet determined by scientific research that is the real morbid principle, and which affects those predisposed to disease, but does not attack others not thus predisposed.

Next in importance to excremental matter is refuse from slaughter houses, tanneries, and allied industries—animal refuse in any shape and from any source. Here we may be met by the objection that much animal matter is consumed knowingly in a more or less decayed stage, such as ripe game, cheese, etc., without, apparently, any ill effect. To offset this objection, many cases of ptomain poisoning might be cited that have resulted from the consumption of spoiled meats, fish, etc.

While numerous facts support the belief that most of the mischief attributed to drinking water is caused by the presence of living organisms, with their practically unlimited power of self-propagation, and not by any chemical substance, it is of course possible that indirectly a large quantity of organic matter in water may be more dangerous than a smaller quantity, as furnishing on a greater scale the suitable material and conditions for the development of noxious as well as harmless organisms.

However views may differ on this most important question as to the possible injury from this and that source, we are safe in accepting the following principles as fundamental guides in the selection of a water for domestic or public supply:

"A suitable water for domestic purposes must be free from all substances that are known to produce an injurious effect on the human system, or which are supposed, with good reason, to produce such an effect.

"The water should be, as far as possible, free from all substances and associations that offend the general æsthetic sense of the community, and thus affect the system through imagination, even if there is good reason to believe it is in itself harmless."

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THE STRENGTH OF A MAN

F. A. Kaiser

BENEFITS OF EXERCISE—SYSTEM OF MAN TESTING—MAN'S HORSEPOWER

AS LONG as men are dependent on their bodily strength for food and personal safety, there is no danger of this strength being neglected. It is said that in the youthful days of our world, man lived in caves in the rocks, from which he ventured only at his peril. He was often forced to use the trees as his highways, and he learned to swing from limb to limb, like a monkey, or to hang from a bough with one hand while he wielded a club with the other. Under

FIG. 1

FIG. 2

such circumstances it was inevitable that man's whole energy should be bent toward developing those powers on which self-preservation directly depended, and strength of muscle was the only manly attribute.

In medieval times the warlike nations always produced the best specimens of physical man, while today the blacksmith and the manual laborer need no gymnastic training to keep their limbs from withering. When men, however, no longer depend on bodily exertion for support, and spend their efforts in what is called "brain work," the body is sure to suffer, for is not the scholar in story books pale of face and thin of limb? Indeed, the time is not long past when a man could gain no credit for studious habits unless his pretensions were supported by a pair of stooping shoulders, a hollow chest, or watery eyes.

With the introduction of athletic training in our schools and colleges came the reaction to this tendency, and young men began to feel not only the joy of mounting an intellectual hill, but the rejoicing experienced by the "strong man about to run a race." Of course, the athletic tendency has been carried to an extreme, just as the non-athletic tendency was before it. Like a pendulum when put in motion, sentiment has swung first far to one side, then far to the other, but gradually approaching the stable medium position. As a result of this steadying tendency, we now find hundreds of students

FIG. 3

and clerks taking general gymnastic exercise, where formerly tens only made athletic specialists of themselves. The increased interest in the strength of men made necessary a rational system of comparison—a system by which the development of two men

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could be accurately compared, though one might work as a hod carrier in New York, and the other at translating Greek philosophy in Boston.

The system now accepted as standard is that proposed by Dr. D. A. Sargeant, wherein the strengths of the more important muscles are determined by direct tests. The strength of the back is found by a lift measured by a dynamometer, as shown in Fig. 1. In this lift the knees must be kept straight, so that all the work is done by the muscles of the back. The table below gives the average back lift of a man 5 feet 10 inches in height as 313 pounds. For the leg lift, the knees are bent as shown in Fig. 2, and the handle of the machine rests on the thighs. In straightening the legs, terrific lifting power is exerted. For the strength of the lungs the test consists of blowing into an instrument very much like a steam gauge, which records the pressure produced. The upper arms are tested both by the push up, as in Fig. 3, and by the pull up, as in Fig. 4, from extended length, until the chin is on a level with the bar. The strength of the forearms is found by taking the gripping power of each hand on a spring dynamometer, as in Fig. 5. All these tests are read in kilograms, 1 kilogram being equal to 2.205 pounds.

As a matter of interest, we show below the record of an actual test made on John Smith, a man 22 years of age, weighing 147 pounds, and 5 feet 10 inches tall.

though it takes into account mere strength, does not consider a man's endurance, which, together with strength, make up his ability to do work. It is evident from the great leg power shown by Smith, that he could do

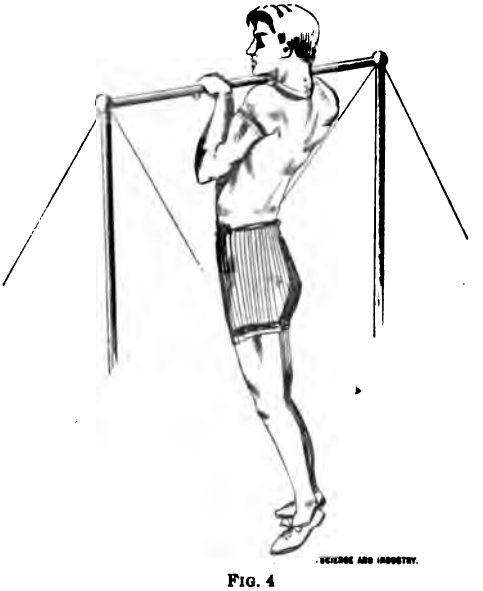

FIG. 4

his best work in carrying weights up a stairway, and it would have been quite interesting to determine how much power he could develop for 10 hours at a stretch. We tried

	Pounds. Average.	Pounds. John Smith.	Kilograms. Average.	Kilograms. John Smith.
Strength of lungs			13.00	18.00
Back lift (Fig. 1)	313.1	425.3	142.00	192.90
Leg lift (Fig. 2)	377.0	850.2	171.00	385.60
Push up (Fig. 3); average No. times, 5.7; John Smith, 10			98.24	153.18
Pull up (Fig. 4); average No. times, 8.3; John Smith, 13				
Right forearm (Fig. 5)	94.8	118.6	43.00	53.80
Left forearm (Fig. 5)	88.0	105.0	40.00	47.60
Total strength			502.24	851.08

The first column shows the strength in pounds of an average man of John Smith's stature. The second column shows John Smith's strength in pounds, while the third and fourth show the same in kilograms. The final score is obtained by adding to the other items one-tenth the weight (66.6 kilograms) multiplied by the sum of the push-up and pull-up scores.

It will be seen that this system of tests, hard to impress on him the duty he owed to science, and requested him to carry a bag of flour under our supervision, but he valued his services too highly to make the test possible.

What is the "horsepower" of the average man? First, let us define horsepower. When Boulton and Watts, about 1800, were first selling steam engines, they assumed a rate so that purchasers who wished to

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substitute steam for horses should not be disappointed. They therefore rated as 1 horsepower any engine that could, at any moment, perform the work of a very strong horse. Since, however, such an engine can work hour after hour without stopping, which a horse cannot, it is plain that a 1-horsepower engine can do much more work than any one such horse. At the same time, the horses that they used as standards were the very heavy English dray horses that were much stronger than the average. It has been found by experiment that the average horse can do only 22,000 foot-pounds of work per minute. In other words, *actual* horsepower is two-thirds of the *nominal* horsepower of 33,000 foot-pounds per minute. As a rough approximation, we may say that the useful daily net work of a horse is about 10,000,000 foot-pounds.

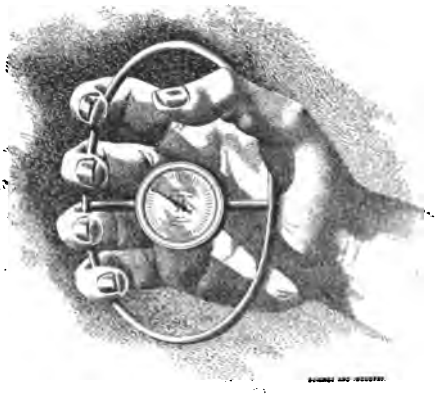

FIG. 5

An average man, pulling a load along a level road, by a rope over his shoulder, can do in 10 hours about one-sixth as much work as a horse. In raising his own weight up a stairway or ladder, a man can do 2,088,000 foot-pounds of work per day, which is equivalent to raising 1 ton about 1,000 feet, or about one-fifth as much work as a horse will do in the same time. Assuming that the man weighs one-tenth as much as the horse, either of these tests shows a man to be nearly twice as strong as a horse in proportion to weight. In carrying a weight up a stairway or ladder, as in carrying shingles from the ground to a roof, he can do only 400,000 foot-pounds of work in 10 hours, equal to raising 1 ton 200 feet.

When turning a crank, such as on a grindstone or derrick, a man can do 1,300,000 foot-pounds in a day; that is, he can raise 1,300,000 pounds 1 foot, or a ton 650 feet in 10 hours. This calculation, of course, ignores friction in the machine. On a treadwheel a laborer will do 1,400,000 foot-pounds per day —rather more than with a crank. A man hammering will do about 480,000 foot-pounds per day, equal to raising a ton 240 feet. A laborer standing still can barely sustain 100 pounds by a rope over his shoulder and thence passing horizontally over a pulley. He cannot push horizontally at the height of his shoulders with more than about 30 pounds force.

A man walking horizontally, carrying only his own weight, in 10 hours will transport an equivalent of 25,300,000 pounds 1 foot. Traveling with a burden, however, he can transport only 5,670,000 pounds 1 foot.

Since a man's best performance, both in raising a load vertically and in transporting it horizontally, is made when he carries only his own weight, it is evident that man wasn't intended to "work."

A POINT IN ADVERTISING

A MICHIGAN man, whose name it is not necessary to disclose, increased his business considerably by an inexpensive plan of advertising that no doubt might be applicable to the business of many of those of our readers that have stores or shops in country towns or villages. The gentleman referred to opened all his letters by very carefully clipping off one end of the envelope so that no rough edges were visible. After quite a number had been accumulated, they were given to the drivers of his delivery wagons with instructions to drop one in the middle of the road every few hundred yards while driving about on their regular trips. The effect was magical. The envelopes looked so much like real letters that scarcely a person passed one without picking it up, and at least reading the address.

The originator of this plan reasoned that no one can pass a letter lying on the road without picking it up and reading the name and business of the man to whom it is addressed, and in this manner an impression is made on the mind that is not soon forgotten.

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SEEING CROOKED

Shah Jehan

WITH SPECIAL REFERENCE TO OPTICAL DECEPTIONS IN ARCHITECTURE

IT IS said that "seeing is believing," but, like many other wise saws, this statement fails to maintain its integrity, for, under the X-rays of incontrovertible facts, its utter fallacy is revealed.

Did you ever use drawing instruments—the T square and triangle, for instance? If you have, you know that a drawing once commenced must be finished with the same instruments, for if you inadvertently pick up another T square, or use different triangles, or even work from different edges of the same, you will soon be floundering in a sea of inaccuracy, and lines that should continue in the same direction, instead of meeting at infinity, as all respectable parallel lines should, intersect within a ten-minute walk of the drawing table.

This is just what is the matter with the eyes; they do not see alike in any direction, and all objects upon which they gaze are distorted. The proof of this is with us the whole time of our waking hours, though we are so used to the deception that the mind unconsciously discounts the information conveyed by the eyes, and, from long experience by a series of comparisons, learns, to a limited extent, to recognize true forms and at least approximate distances.

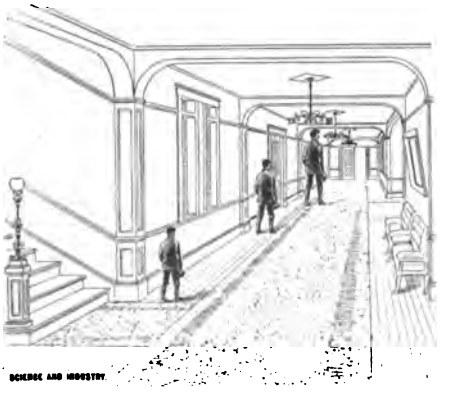

FIG. 1

An every-day optical illusion, so familiar to us all, is that of perspective, in which all parallel lines seem to meet in a somewhat hazy though more or less definite point. Nowhere is this illustration so clearly seen as when we glance along the straight silvery lines of a railroad over which the express is fast becoming a diminutive toy, and the rails, telegraph poles, and fence lines seem determined to meet and intersect away off down the line, as far as the eye can reach.

Look at yonder station by which the train is just passing. If you hold a coin at arm's length it will more than cover it, and yet we know that it is a thousand times larger than the coin, though it is a small building. How, then, is it that we know the building is not large? We have never been closer than we are at present, and yet we are positive that the station is comparatively small. There, that word "comparatively" expresses all—everything is judged by comparison. We know how large a window usually is, and also a telegraph pole. The first, located in the side elevation toward us, is a unit of comparison for the area of the side, and the pole near by shows the altitude of the ridge. Thus it is that the mind is constantly guarding against the deceptions of the eye by making comparisons between objects of familiar dimensions and those of unknown size; it is in this way, and only in this way, that distances and bulk can be even approximated.

The mind, however, is not always on its guard, and like the small child reaching out to grasp the moon, sometimes fails to measure distances correctly, the individual being cruelly deceived. Such miscalculation of distance is a familiar occurrence, and many curious and interesting stories are told of people who, having lived in a heavy and hazy atmosphere, find themselves, when sojourning in the dry air of the Rockies, starting out for a short walk before breakfast to yonder mountain or hill, which, after giving it up in disgust, they find to be 20 miles away. So it is in a foggy atmosphere; a ship on the sea looms up like an iceberg, and a pastoral stroll is fraught with terror to a nervous person, who sees a ghost in every fence post and a beast of overwhelming proportions in the wood pile.

In this age of cheap and rapid transportation, we have all traveled somewhat, and whether we look from the window of a slow-moving train or from the deck of

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a ferry boat nearing the wharf, we have repeatedly been struck with the appearance of motion in the stationary objects around us. The phenomenon is so strong that it is

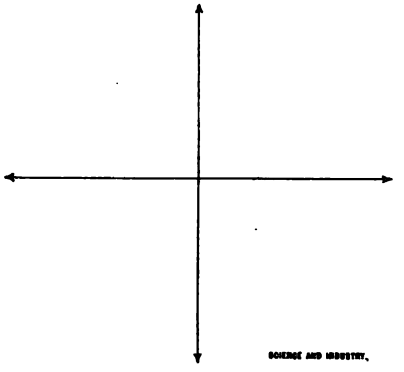

FIG. 2

with difficulty we realize that it is ourselves who are in motion, and not the landscape or near-approaching shore. This illusion is often more evident when, comfortably seated for a long journey by rail, we look from the car window to the opposite track. Is it the freight car or is it the day coach that is in motion? It is evident we cannot tell by looking at the side of the freight car, and as we feel no jar from our own coach, we naturally look for the revolution of the wheels under the freight before we can

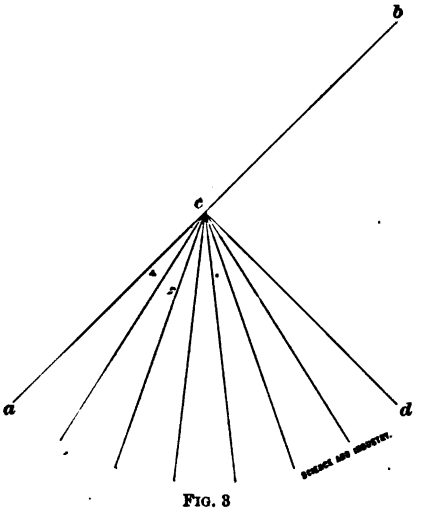

FIG. 3

positively know which train is in motion. The mind is in much the same condition when deprived of landmarks or guides by which to judge sizes or distances. How can we prove this? Easily enough. Suppose we show numerous objects in perspective, and on the same drawing several of like kind not in perspective. We are accustomed to seeing all objects in perspective, and, consequently, being thus deceived, the objects not in perspective appear to be larger than they really are.

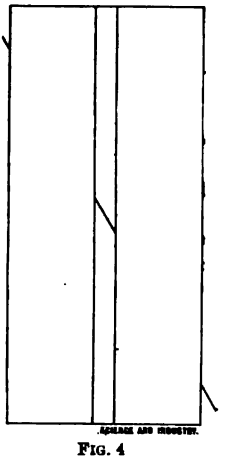

FIG. 4

Look at Fig. 1. The three men are of one height. They certainly do not appear the same, but if we measure them with a pair of dividers we will know that the artist has made them so. You will notice in the picture that the long corridor is in perspective, while the men, although apparently some distance apart, have been drawn to scale, and are shown in their true size. Thus the mind, being used to comparisons and the perspective image produced by the eye, makes its usual calculation or reduction for distances, and is consequently deceived.

The eye, owing to its construction, places everything in perspective, but besides this

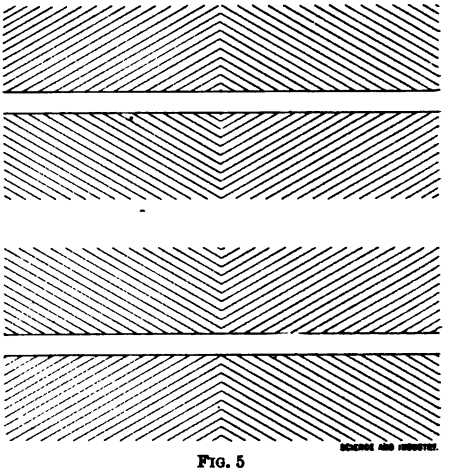

FIG. 5

it does not see the same in an upward and downward direction as it does in a horizontal direction. This can be demonstrated if we put a sheet of paper on a board and, holding it directly in front of the eye, mark

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a dot on the paper. This dot will be the point of regard looking straight forward; from this dot draw what appears to be four lines of equal length, two vertical (one upwards and the other downwards), and two horizontal (one to the right and one to the left). On measuring the seemingly equal lines, it is found they are far from being of the same length. Neither of the vertical lines will be as long as the horizontal ones, and the upper vertical will be

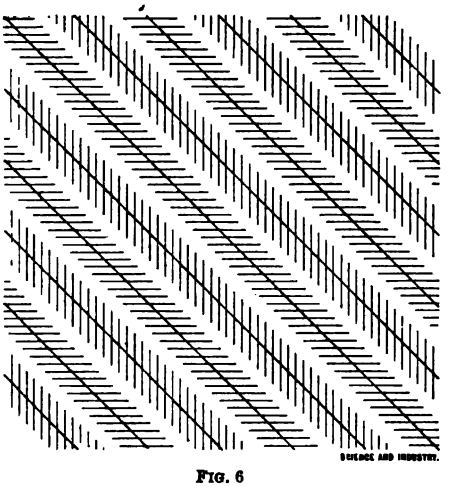

FIG. 6

much shorter than the lower. The lines that we really traced are as shown in Fig. 2. The conclusion to be drawn from this is that the space above the point of regard is overestimated when compared with the space below, and both are foreshortened when considered with the space to the right or left.

The mind, in judging of form, space, or distance through the eye, always exaggerates the small things and gives them greater value than they possess. In Fig. 3 the angles formed by lines *ab* and *cd* are exactly the same, but the angle to the left certainly appears the larger; the broken line in Fig. 4 is part of the same line, although you would hardly think so from a casual observation. From this we know an acute angle always appears larger than it is; in other words, we always overestimate the extent of the angle. Many very interesting and puzzling illusions are due to this failure of the mind to grasp through the eye the true extent of angles.

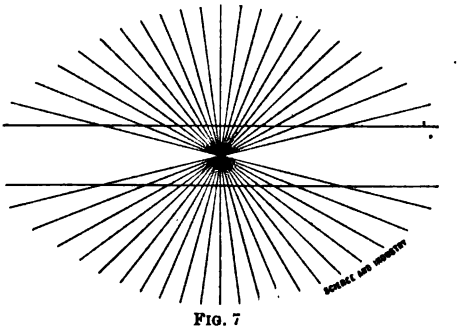

FIG. 7

To illustrate, suppose we draw two straight parallel lines and from the center of these lines cross-hatch either way with a 30° triangle. The result is startling, as can be seen

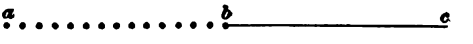

FIG. 8

in Fig. 5, for it will be observed that the lines no longer appear straight, but seem to be bent outwards or inwards, depending on which way the cross-hatching is drawn.

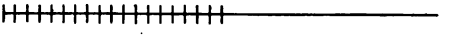

FIG. 9

The direction in which they appear to bend is always the direction in which a line would have to be drawn in order to increase the acute angle. Another illustration of this curious phenomenon, governed by the same principle, is shown in Fig. 6, and still another in Fig. 7. The principal lines in

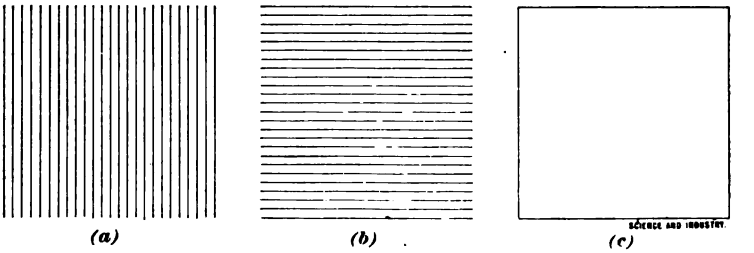

FIG. 10

these figures are parallel in spite of their erratic appearance.

There is a curious illusion produced by the fact that when the point of regard looks upwards it has a tendency to move

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outwards, and when it looks downwards it tends to move inwards. Look at the numeral 8 and the letter S. Observe them carefully, and then turn the magazine upside down; the distortion is immediately noticeable. In

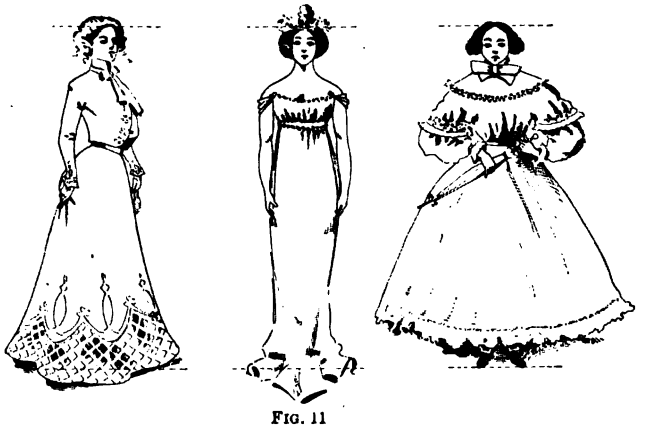

FIG. 11

walking along the business block of a large city, how overwhelming are the high buildings on either side. As we look at them from one side of the eye, they appear to lean dangerously, like the young lady just out of school, impressed with the desirability of physical culture, practicing the Delsarte walk; while glancing at them from the other side of the eye, they appear to shun the street, somewhat like the Quaker who is so straight that he tips just a little bit backward.

In glancing along a line, the sight follows it uninterruptedly and easily, but if the line is crossed or broken at intervals the eye halts and rests, as it were, the same as a person out for an aimless stroll. When distance is interrupted, it seems longer in comparison than it is in reality, as reference to Fig. 8 will reveal. The distance from *a* to *b* is the same as from *b* to *c*, but, on account of the numerous rests, or way stations, on which the eye stops in traveling from *a* to *b*, this distance to the mind is considerably longer than from *b* to *c*. Similar comparisons can be made in Fig. 9, and the three squares shown in Fig. 10 have equal sides. This is difficult to believe, for (*a*) appears wide and flat, while (*b*) seems of greater height than width, and the only true square is apparently the one shown at (*c*). In (*a*) there is no vertical interruption for the eye, and it travels along the lines easily, but, in glancing across the figure, the vertical lines interrupt the vision, and the square is distorted to a rectangle standing on its larger base, and the width seems greater than the height. At (*b*) the opposite effect takes place: the horizontal lines are shortened, and the vertical height of the figure increased on account of the numerous stops the eye makes in traveling to the top of the figure. The only true square, to the eye, is at (*c*), for as there are no cross-lines in the figure, there is no illusion. From this we see why it is that the girl in the tailor-made gown looks so tall and stately, while the country lass, in the paraphernalia of the church picnic, with her muslin dress and numerous pink and blue ribbons, looks far shorter and considerably less stately, though undoubtedly like an angel to the village swain.

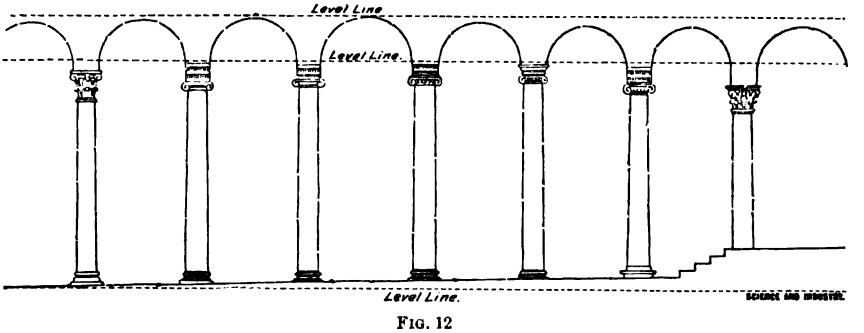

FIG. 12

Many other optical illusions might be mentioned; they are so numerous, however, that we need only consider one other, the

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illusion in height by comparison of areas; that is, the contrast between breadth and length. In sizing up the height of an object, the mind, through the eye, is very apt to compare areas, and, by the comparison, the judgment of the individual is

builders even went further than this. They not only corrected the appearance of anything that, owing to the organism of sight, failed to look as it really was, but, by peculiar devices, they exaggerated the true perspective, and gave both the exterior and

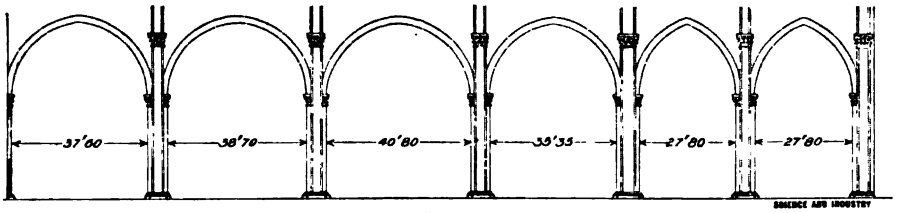

FIG. 13

influenced in favor of the body having the larger area. In Fig. 11 the three girls are all of the same height. The one in the Empire gown appears the tallest, while the one in

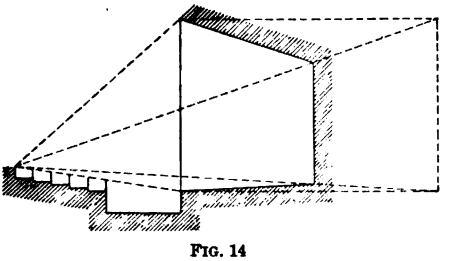

FIG. 14

the hoop skirt of the time of Buchanan's administration looks somewhat shorter, and the up-to-date girl to the left is the happy medium. Broad objects appear shorter, and narrow objects taller or longer than they really are.

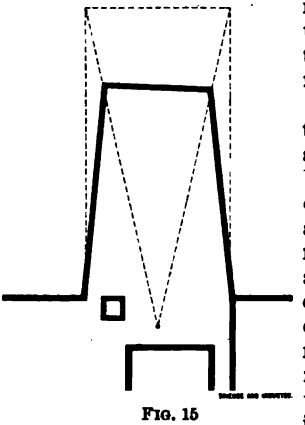

FIG. 15

What has all this to do with architecture? We might say everything, and again nothing. The ancient and classic builders and those masters of the middle ages, with fine feeling and keen perception, realized how important it was to make allowance for deceptive vision, and to so construct buildings and proportion details that the lines of beauty would not be destroyed. In fact, the Italian church

interior an appearance of distance and vastness they did not possess. They were well aware of the oppressiveness created in the individual when the sight is directed upwards between parallel lines, and the greatest artists among them flared such lines outwards, and thus obtained an appearance of lightness and beauty.

That the Egyptians thoroughly understood how the eye could be deceived and the mind made to realize a perspective that never

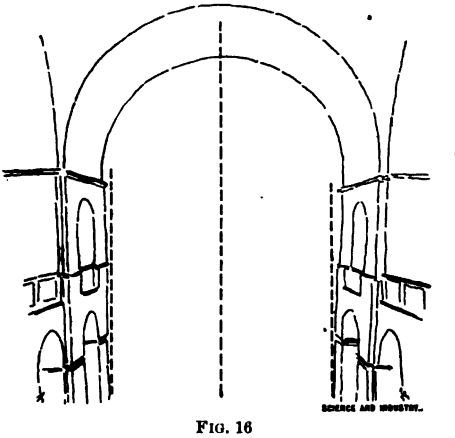

FIG. 16

existed, cannot be doubted, for Rawlison, in his "History of Egypt," said, "The contrivance for augmenting the apparent size of buildings which we have to speak of, in conclusion, is the following: Egyptian buildings of large extent have the most apparent rise as we penetrate into them. When we pass from one limb to another, we generally ascend a few steps. Sometimes, however, the ascent is more gradual. At the Ramesseum, and again at Edfu, the level of the ground rises from column to column, each column being placed on a low step a

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little above the preceding one. The effect is similar to that produced in a modern theater by the sloping of the floor to the back of the stage. It is aided by the general arrangement of doors and pylons, which

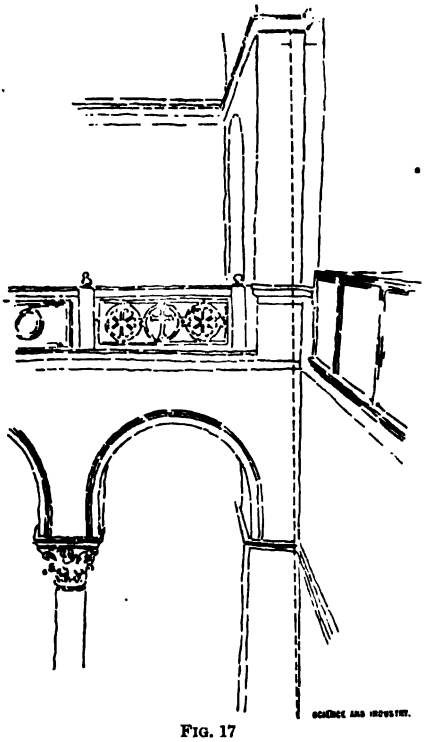

FIG. 17

diminish in size as we advance. · An illusive perspective is thus obtained. The vistas of pillars seem twice the length they really are, and the entire building appears to be of a length almost interminable."

The Greeks, originators of classic architecture, did not apparently practice deceptions on the eye, but they did endeavor to correct erroneous impressions created by the sight. They understood fully that long parallel vertical lines, such as would bound a cylindrical column, appeared hollow or concave, making the support look inefficient and incapable of sustaining the mass of masonry it was required to uphold. To obviate this, they curved the profile of the columns, or gave them what is called the entasis, the purpose of which was to overcome this optical illusion. Not only did they swell the sides of the column, but they also cambered the horizontal and vertical lines of the building itself. This curvature of outline was maintained throughout the entire building, and in consequence there is hardly a straight line in the structure. The lines of the corners, pediment, steps, and side walls all have a slight entasis, varied in amount to suit the particular case.

Much of the beauty of classic buildings is due to the knowledge their constructors possessed regarding defects, or, rather, effects, of vision. To them we are indebted for the most refined methods of obviating these optical illusions. Without such refinement as the cambering of the cornice across the front of temples, they would appear to sag from the mass of material and apparent weight in the center of the pediment. In the Parthenon, the architrave and frieze slope about 1 part in 80 toward the center, in order to avoid the apparent depression that would exist if they had been built as the mathematical architect of today would have designed them. For somewhat similar reasons, the corner columns of buildings were made larger, so that by contrast they would not seem weak and less able to carry their load than the intermediate ones.

In the year 1895, William H. Goodyear, in connection with the Brooklyn Institute, made an extensive survey of the Italian cathedrals in order to ascertain to what extent, in the construction of the buildings, means were employed to deceive the observer and to trick the eye so that the individual would be led to suppose conditions that did not actually exist. He found on careful survey and accurate measurements that many contrivances were used for this purpose, the principal one being illusions in perspective, which were obtained in the several ways practiced extensively by the modern theatrical scene painter. The long nave of these churches, flanked on either side by aisles separated from them by arcades, offer the best chance in the world for a distorted perspective. It was found that they sloped the floor upwards or dropped the height of the arches as they advanced toward the choir, in many cases even converging the walls and varying the dimensions between piers. They did not always commence these reductions in the height of the arches and the spacing of the piers directly at the entrance of the church, but often began the deception part way down the length of the church, at the place where the eye would naturally rest on first glancing toward the choir

In Fig. 12 is shown a longitudinal section of S. Saba at Rome, with a rising slope of the pavement toward the choir of 1 foot in

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the length of 50 feet. The lines of capitals rise at the entrance, then drop toward the choir. One might naturally think that such a condition was produced by unequal settlement. This cannot have been the case, for the arrangement is the same on both sides, and occurs not only in one church but in many. Frequently, the width of the spans in the arcade was diminished, the amount of diminution being considerable, as shown in the longitudinal section of S. Maria Novela at Florence (Fig. 13). It will be noticed that the greatest span is 40.80 feet, while the least is 27.80 feet, a reduction of 13 feet in the direction of the choir. The effect of all this is readily discernible when we refer to Fig. 14, which shows the apparent increase of size obtained by the modern stage setting. Notice that the floor slopes upwards and the overhead scenery downwards, and observe how the eye is deluded into believing the stage to be twice its real depth, the illusion being augmented considerably by the converging of the scenery in either wing.

The converging of the walls is a common occurrence, and exists in many Italian churches and buildings. Not only is the interior effect obtained in this manner, but the exterior perspective is also apparently increased. This is especially marked in S. Giorgio at Velabrum, Rome, where the walls converge toward the choir 17½ feet in the length of 81 feet. In Fig. 15, a plan of the Piazza of S. Marco at Venice shows the apparent increase of dimensions produced by the converging side of the Piazza, for in this figure, as is seen by the dotted lines, the depth of the perspective is increased to the eye at least 50 per cent.

There were many other devices practiced by the master builders of the middle ages that are subtile and difficult to discern, and have as yet been undiscovered. Not only were these illusions practiced in large cathedrals and churches, but even unimportant buildings were sometimes constructed to deceive the observer into imagining distances that never existed. On one small church, San Stefano, outside the walls at Pisa, the corbeling along the cornice of the clearstory is diminished as it retreats from the front to the rear. Not only are they made less in depth, but the distances between the corbelings are reduced.

A few words more to show to what extent the architects of these churches understood illusions of sight. In St. Mark's, at Venice, the piers supporting the principal arches are sloped outwards at the top. This increase of span between the base of the pier and the spring of the arch cannot be accidental. They were too careful builders for that, and it is not possible that the thrust of the arch produced this deflection from the vertical; for, had it occurred, the original mosaic would have been destroyed, and, in fact, the vaulting itself could not have withstood such a serious change of form. Notice the outward flare in Fig. 16, which is a sketch of the interior of St. Mark's, Venice, from the façade gallery. The total widening of the piers is 2.9 feet. Fig. 17 shows how the wall at the north transept in the same building is flared outwards over 1½ feet. They even spread the window openings somewhat, flaring them, the same as the piers, outwards toward the spring of the arch. The façade of S. Ambrogia, Milan, shows this plainly, as can be seen from Fig. 18. This manner

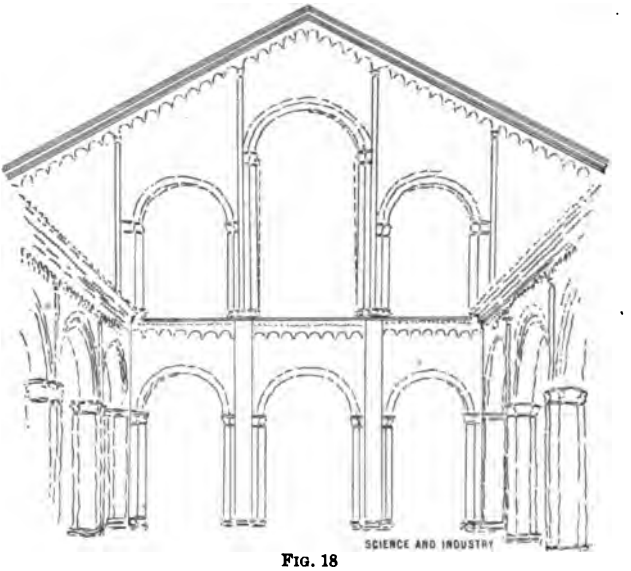

FIG. 18

of building is different from that practiced today, for the architect uses his level and plumb-line continually, and a deviation from one or the other is a serious fault that the contractor must correct.

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We see strange sights in large cities as we look at and note carefully the architectural effect produced by the heterogeneous buildings in close proximity. One place we note a building with a very steep roof against which the stone finials of the dormers stand out in strong contrast. If we get a side glimpse, where the sky line of the sloping roof falls adjacent to the vertical finial of the dormer, the finial seems to lean badly. The effect is startling. Again, the Gothic spire of some near-by church will throw the plumb corner of an office building away out of line, and a flagpole, from like causes, will seem far from vertical. In modern work, all these difficulties cannot be remedied, but, by careful study of optical illusions, the buildings can certainly be made more pleasing in appearance—more graceful and lighter in effect—than they often are, and tall buildings may be apparently lengthened by corbeled string courses or carefully disposed moldings, which arrest the attention and destroy all tendency toward perpendicularity.

POTENTIAL ENERGY

George S. Hodgins

STORED UP KINETIC ENERGY—SAME AMOUNT EXPENDED WHEN CHANGING FROM ONE STATE TO THE OTHER—ELECTRICAL ENERGY—ENERGY STORED IN PLANTS

TYNDALL tells us in his "Fragments of Science" that "a body cast upwards consumes the actual energy of projection and lays up potential energy." A stone, therefore, if thrown vertically upwards, moves against the attraction of gravity, and will continue to go up until all the energy it had received has been expended in motion, when it will pause momentarily in mid-air and then begin to fall. If at the instant of its pause the stone is caught upon a projecting shelf or beam, it will lie there perfectly inert; all the energy that had been imparted to it in sending it skywards will have been used up, in order to enable it to reach its resting place. Its active, or, as it is called, *kinetic, energy* has disappeared as such; but in its place, the stone now has stored up energy, with reference to its starting point, which may be called the *potential energy* of position. The stone now possesses the *capability* of doing work—of causing pressure to act through distance—if once it can move down again, and no lapse of time can alter the amount of this stored up energy. If the stone is pushed off the edge of its support, it will instantly begin to fall, and, increasing in velocity as it goes down, will do the same amount of work in coming to rest at the level from which it started as was imparted to it when sending it upwards. The kinetic energy has again been transformed into potential energy; but, in this case, the potential energy is not that of position.

Another example of potential energy may be seen in the familiar operation of winding up a watch. Active muscular energy of the kinetic kind is transmitted from the hand of the operator to the mainspring of the watch. The molecules of the spring are forced, each slightly out of its normal state, and made reluctantly to assume a new position, in which the steel is under stress. The spring has received the actual moving energy of the operator's hand, storing it up and hiding it for the time being in the slight molecular distortion of the spring. The spring now possesses what, for want of a better name, may be called the potential energy of molecular displacement. This potential energy stored up in a few seconds will be given out by the spring, slowly and steadily through the succeeding hours, and expended in driving the wheels and hands round and round, against frictional resistance. The molecules of the tempered steel, one by one, will assume their normal positions as the escapement of the watch gradually and rhythmically frees the potential energy and renders it kinetic, in the form of heat and visible motion. The inert and lifeless spring acts solely to regain its *status quo* when wound up, by reason of the active energy it has received and stored up in the compulsory displacement of its molecules. No hidden virtue resides in the tempered steel; its only utility is its ability to maintain for the time the stress of molecular distortion, rather than by rupture instantly liberating the kinetic energy with which it has been supplied. It is simply the vehicle

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through which the kinetic energy of a moment is stored up in the potential form, and liberated slowly in the task of counting the fugitive hours.

Electricity may exist as static charges, and under such circumstances it is in the potential state. When the plates of a static machine are revolved, electric charges are induced, and these charges may be collected on the coatings of a Leyden jar. The muscular energy exerted in revolving the plates of the machine thus becomes stored up as potential energy, and, although an electrical tension exists between the inside and outside coatings of the jar, no resistance is being overcome and no work is done. If a wire is connected to one coating and then brought near the other coating a spark will jump across, and the potential energy will be dissipated. The stored up potential energy thus becomes active—work is done in forcing the discharge through the air, and the discharge is also accompanied by a flash of light and a certain amount of heat. The discharge has thus given back the energy that was expended when the plate of the static machine was revolved.

We now come to even a more interesting example of this wonderful potential energy, the one *par excellence* on which depends all our industrial achievements and material advancement and success. It is one of the peculiar characteristics of all plants that they are able, by means of the chlorophyl, or green coloring matter of their leaves, when bathed in the sun's rays, to separate carbon out of the carbonic-acid gas of the atmosphere, and, retaining the carbon in their own structures, to liberate the oxygen. The growing plant exerts this disintegrating power; it forces apart two substances already combined—carbon and oxygen—retaining the one and dismissing the other. In doing so, it has rendered latent, or to speak more correctly, it has stored up energy. It has seized upon an inert compound, torn the united molecules apart, and has thus isolated the two simple substances of which it was composed. In so doing it has done work in its own peculiar way, just as certainly as that done in drawing back the armature from the grasp of a permanent magnet. It is to the energy derived from the sun that this wonderful transformation must be ascribed. Its light, heat, and chemical or actinic rays pour upon the earth, and falling upon plants of all kinds, afford them the means of using the energy so lavishly expended in adding to their own substance. The oxygen turned loose on the atmosphere has not lost its affinity for carbon. It retains that as strongly as before, so to speak. More correctly, the separation endows the carbon particle and the oxygen particle with the possibility of an energetic union, which can never be destroyed until complete union is again restored. The isolated carbon and oxygen are said to possess the potential energy of chemical separation, like an elastic band stretched, requiring only to be released to fly back to its former inert position.

The separation of carbon and oxygen that is effected by plants in the presence of sunlight is, in a certain sense, analogous to what is done in a storage or secondary battery. In it there is a galvanic cell that contains a compound body which is really a chemical union of two elements. The compound is inert and passive. Let us suppose that an electric current is passed into this cell. The current acting on this compound, which possesses no energy, will slowly isolate its elements. It will force these differing atoms held in close union to unloose their grasp one from the other, and will move them apart, through a certain definite distance. At the end of the operation all the atoms of one element will be found clustered around one pole of the battery, and those of the other element will adhere to the other pole. The separation of each group of elements will be as distinct and as clearly marked as would be the separation of oil and water, when allowed to come to rest within the walls of some containing vessel. In effecting this separation of elements, the kinetic energy of the current has been expended; it has chemically separated the atoms, and in so doing has given them the potential energy of chemical separation. When the now isolated bodies are connected by suitable means and the current withdrawn, they begin to unite again chemically, and in doing so liberate the separate energy in the form of an electric current, which flows back over the connecting wire.

We have seen what is meant by the potential energy of chemical separation, with reference to carbon and oxygen. The formation of coal is a natural process in which the flora of a bygone age, with its isolated carbon, has been submerged and packed down under the weight of thousands upon thousands of tons of mineral matter, to the entire exclusion of the air, and before the process of rotting, which is simply slow burning, has taken place. Under this enormous pressure,

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deprived of air, the mass of vegetable matter has lain for untold years, its moisture and its life gone. Still it has rested there, with the unappeased longing, if one may so say, for the union it once had with the oxygen of the air.

In the later days, when the coal has been dug up, broken, and thrown upon the grate, when the necessary temperature condition has been reached for which it has waited through centuries, it bursts into flame and gives out the energy that had been stored up in separating it from the oxygen, in the days when the earth was young. It now gives its energy back in the form of light and heat, and the inert compound, which existed long ago, is the result. It is in virtue of this potential energy of chemical separation that coal, and indeed all fuels, have their value in the eyes of man.

It was therefore true in substance, though somewhat poetically expressed, when George Stephenson said to Buckland, as they were watching a moving train, pulled by one of the great engineer's new engines, at a time when such things were novelties: "It is light bottled up in the earth for tens of thousands of years—light absorbed by plants and vegetables, being necessary for the condensation of carbon during the process of their growth, if it be not carbon in another form—and now, after being buried in the earth for long ages in fields of coal, that latent light is again brought forth and liberated, made to work as in that locomotive, for great human purposes."

[This article deals with one of the most beautiful and important hypotheses that have ever been enunciated by physicists—the *conservation of energy*. According to this hypothesis, energy, like matter, cannot be destroyed; the total amount of potential and kinetic energy in the universe is the same now as it was ages ago, and will continue to be the same for all ages to come. In Mr. Hodgins' first illustration, that of a stone thrown upwards, the kinetic energy at the start was a certain amount, say 100 foot-pounds per second, and the potential energy zero. At one-fourth the height that the stone ascended, the potential energy was then $100 \times \frac{1}{4} = 25$ foot-pounds per second, and the kinetic energy $100 - 25 = 75$ foot-pounds per second. At all stages of the ascent the sum of the potential energy and kinetic energy was 100 foot-pounds per second. At the instant that the stone reached the highest point, the potential energy was 100 foot-pounds per second (or, rather, 100 foot-pounds, since no time can be specified) and the kinetic energy zero. During the falling of the stone, the operations are reversed—the potential energy is decreasing and the kinetic energy is increasing. But what happens when the stone strikes? If it has sufficient energy, the stone will bore its way into the ground; the resistance offered will transform the kinetic energy of motion into the kinetic energy of heat, which in turn increases the temperature of the surrounding air, and becomes potential energy once more. The energy is not lost even now; it will manifest itself again under different conditions, although it may appear to be lost, owing to its exceedingly small amount compared with the local potential energy in the atmosphere. The general tendency seems to be for the kinetic energy to change to potential energy, and the time will undoubtedly come when the kinetic energy of the earth and its atmosphere will have all changed into potential energy. Long before that time comes, all living things will have ceased to exist; the gases composing the earth's atmosphere will have been solidified—in other words, the skies will have fallen—and the earth will then resemble the moon; but the total amount of energy in the universe will be the same then as it is now.—ED.]

RUSSIAN WEIGHTS AND MEASURES

THE new regulation of the Russian weights and measures was officially published August 18, 1899. The metric system is recognized, and its use is made optional. The Russian pound is made the standard of mass and declared to be equal to 409.512 grams; a vedro is to contain 30 pounds of distilled water at a temperature of 16.6° C., and a garnetz is to hold 8 pounds of water at the same temperature; the unit of length is the arshin, which is declared to be equal to 71.12 centimeters. It is worthy of notice that in these regulations the pound is a standard of mass and not a standard of weight, and that the Russian measures are defined in terms of the metric system.

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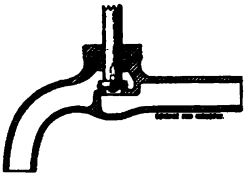
USEFUL IDEAS

GRINDING FAUCET SEATS

J. F. M., Rochester, N. Y.

ABOUT six months ago I had occasion to grind down the seat of a ½-inch hot-water faucet, and, not having reamers, I prepared a round stick to fit in the faucet when the stem was removed.

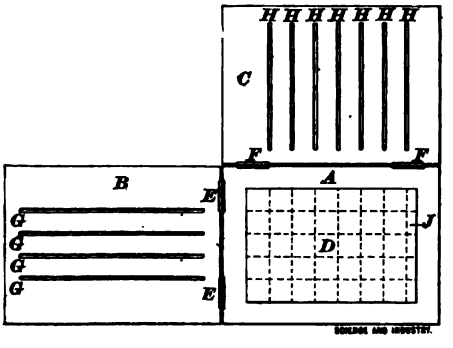


On the end of this stick I fastened a washer made of hard rubber of the same size and kind as used in the faucet; and on the face of the washer I secured a piece of emery cloth by means of a screw, as shown in the sketch. I then put the stick in a brace and turned it until the seat was ground, renewing the emery cloth when necessary.

APPARATUS FOR CUTTING SMALL RECTANGLES OF GLASS

F. E. Rogers, East Orange, N. J.

WHILE in the shops of The National Meter Works, in Brooklyn, N. Y., I saw the simple and effective device shown in the accompanying illustration, for facilitating the cutting of the small glass covers required over the registers of water meters. The apparatus is simply a board *A*, to which are hinged the two boards *B* and *C*, the hinges being

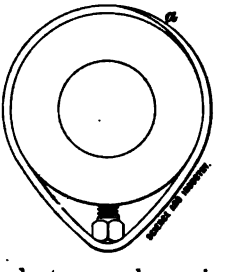


indicated at *E*, *E* and *F*, *F*. The boards *B* and *C* have narrow slots cut through them, as shown at *G*, *G*, *G*, *G* and *H*, *H*, *H*, *H*, *H*, *H*, *H*, which are for guiding the diamond glass cutter. The operator, when using the appliance, lays a plate of common window glass *D* on *A* and then folds over the board *B*. The longitudinal cuts are made through the slots *G*, *G*, *G*, *G*, which guide the cutter in a straight line and also give the correct spacing. After cutting the longitudinal lines, the board *B* is turned back and the board *C* turned over the glass so that the lateral lines may be cut in the same way as already described. The seventh dotted line at the right shows that the glass "cuts to waste," the narrow strip *J* being rejected. After the longitudinal and lateral lines have been cut, the operator dexterously breaks the rectangles apart, the whole operation being performed in less time than that required for reading this description. While extremely simple, the obvious utility of the device will undoubtedly commend itself for the cutting of small sections of glass for other purposes than that mentioned.

SAFETY GUARD FOR SETSCREWS

C. B.

I SUBMIT herewith a sketch that shows a device by which the setscrews in collars and pulleys may be protected so that there will be no liability of people having their clothes caught by them and thus jeopardize life or limb. It is an inexpensive device, and consists of a short piece of leather belting passed over the setscrew and spliced at *a*, as shown in the accompanying figure. I trust that this little scheme will be of use to some that have under their management much moving machinery close to employes.



EMERGENCY FUSE PLUGS

J. W. Hooley, South Boston, Mass.

A SHORT time ago, while working in a building, I had a little experience that may be new to some of your readers. A short circuit occurred in one of the lamp sockets, blowing the fuse plugs in the cut-out, thus putting out the lights on that circuit. It

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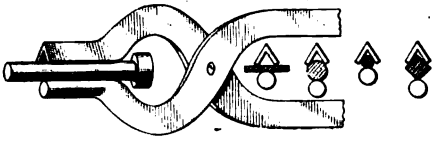
was the work of but a few moments to locate the defective socket and replace it with a good one, but as the shop was a half hour's ride, and as the lights were in demand, something had to be done immediately. In the emergency, I took two burned-out lamps, and after breaking them, twisted together the two leading-in wires. These served as plugs till I secured two of the proper style.

BLACKSMITH TONGS AGAIN

F. W. Wild, Baltimore, Md.

I HAVE used tongs like those shown in the cut, in the manual-training school here, for



a number of years. These tongs will hold a greater variety of shapes and sizes than those described in your issue of last August, and hold tighter. The advantages of the V groove and the opening, or spreading, at the back of the jaws are obvious.

ANOTHER METHOD FOR BENDING IRON CONDUITS

Lon Kalischer, Lakewood, N. J.

I NOTE the remarks of your Ohio correspondent, in the April issue, in relation to

FIG. 1

the bending of iron armored conduits. Aside from the fact that it is contrary to the underwriters' requirements here, he goes some distance to accomplish the same thing we have been doing with less preparation. In the case of the bend, or ell, with the 7-inch radius, the entire stress is, by his method,

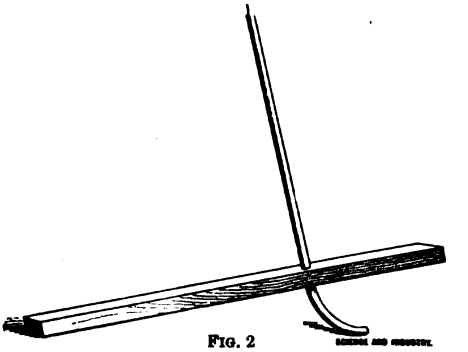


FIG. 2

on the outside portion of the conduit inserted in his base block, and comes, I believe, uncomfortably near flattening the end, especially if the end is threaded. What most of the "boys" use, when it is necessary to "snake" in a bend, is a piece of

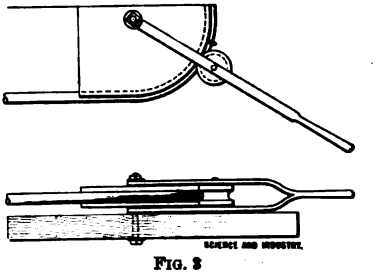


FIG. 3

$2'' \times 4''$ spruce, about 4 feet long, about a foot from the end of which is bored a hole just large enough to readily admit the pipe. It is used as shown in Fig. 1. When necessary to make an S bend, or one to permit the conduit to reach a side bracket from the center of the floor where there is not enough clearance to use a regular ell, the first bend is made as shown in Fig. 1, and the $2'' \times 4''$ piece is then laid on the floor and completed (see Fig. 2). In 1896 I made a jig to bend

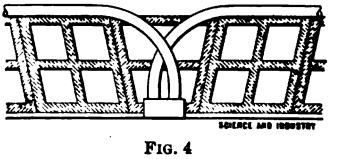


FIG. 4

pipe, which was a little more finished in detail, but it did not seem to take very well. This is shown in Fig. 3. The combination contained a vise that could ordinarily be used

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for cutting and threading, and when necessary to make a bend the end was securely clamped in the vise, after first having been inserted between the roller and bending block, and the lever then brought forward; at the same time pressure was brought to bear on the end of the pipe not clamped in the vise. The block and roller of this jig was, of course, semicircular at the edges, as shown. While this scheme at the time looked very feasible, it does not, I think, compare very favorably with the plain piece of $2'' \times 4''$ spruce, any quantity of which can be had in any building during the course of construction. Again, the fireproof foreman would likely have a word to say if the center of a flat arch were cut to admit the conduits in the manner shown in Fig. 1. It would more than likely be something like Fig. 4. If the conduits cross one another, a hole not much larger than the outlet box is necessary, and as fireproofing is not the nicest thing to cut to measurement, the less cutting the better. Where more than four bends, or ells, are necessary, a curled German silver spring is usually used, to the end of which is soldered a small brass bullet-shaped nosing. The spring is about $\frac{1}{8}$ inch in diameter and from 9 to 15 inches long. This is usually soldered to the end of the "snake" and inserted in the tube first, as it readily takes the ells. I have "fished" six ells with this spring as readily as I have three ells with the ordinary loop-ended snake.

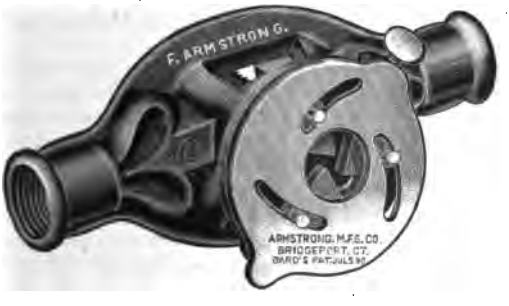
EDITORIAL COMMENT

THE DIESEL MOTOR

We have received a pamphlet containing copies of a number of letters in which users of the Diesel motor in various countries give their experience with the motor and recommend its use to others. The pamphlet is printed in German, and was sent to us by the Russische Diesel Motor Company, Nuernberg, Germany.

THE BARD ADJUSTABLE BUSHING

The Armstrong Manufacturing Company, of Bridgeport, Conn., have brought out a new appliance for use with die stocks of all sizes, which is shown in the accompanying illustration. Instead of the usual bushing for steadying the die on the pipe, there are



three hardened jaws, movable in or out by means of a cam-plate with curved slots engaging a projection on each jaw. When set for any particular size of pipe, it may be locked by a thumbscrew provided for this purpose. This device possesses two advantages over the ordinary bushing: First, it can be adjusted to closely fit the pipe, which prevents the cutting of drunken threads. Second, it does away with the necessity of carrying a lot of bushings around to suit the different sizes of pipes encountered. It is made to fit any die stock, and will take any size of pipe within its range. Any further information in regard to this device can be obtained of the makers.

HIGH-CLASS MANTELS

Now that the cost of buying and erecting wood mantels and fireplaces can be figured to an exact amount, a large number are being used. To accomplish this end, the Alcott, Ross & Scully Co., Philadelphia, Pa., have done more than all other houses combined. Their special process of mounting the tile on slate, so as to be readily set by any mason, has been wonderfully successful, giving a thoroughly first-class job, which is seldom attained elsewhere, except, probably, in the larger cities. In addition to this they offer to prepay freight, the goods to be sent on approval and returned at the expense of the shipper if found unsatisfactory. This offer applies to all goods shipped east of the Mississippi River and north of South Carolina, with an equalization in case goods are ordered outside of these limits. They offer a complete line of goods direct from the factory. Their illustrated booklet containing prices will be sent free, and will be a safe guide in solving the mantel problem.

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NOVEL MUCILAGE TUBE

We have received from The Weis Binder Company one of their Weis brush mucilage tubes. This is a decided novelty. The tube is shaped like an ordinary paint tube. On removing the metal cap a brush is exposed, and the mucilage is fed to the brush by squeezing the tube. It is a very handy and convenient article.

STEEL-WIRE CLEANING BRUSH

The Pilley Packing and Flue Brush Mfg. Co., 318 North Main Street, St. Louis, Mo., have recently placed a wire brush in the market which should prove useful to any mechanic. It is in the form of a flat brush, but, instead of being made of bristles, the brush is made of finely tempered steel wires. It may be used for cleaning the flanges of cylinders and pipes when new gaskets are to be put in; it is well adapted for cleaning boiler fronts, smoke pipes, and other fittings preparatory to painting; it is also intended for the cleaning of files, castings, the removal of rust, and similar work. If this brush cannot be obtained from dealers, send 25 cents in stamps to the makers for a sample.

BOOK NOTICE

Talks to Young People. By Henry Sabin, LL. D. 12mo, 92 pages. Educational Exchange, Manhattan Building, Des Moines, Iowa. Price 75 cents.

The author of this little book was principal of the High School of Clinton, Iowa, from 1874 to 1888, inclusive. Annually during that period he delivered a short address to the graduating class. These addresses, together with one in 1891 to the alumni of the same school, make up the contents of the book. In reading them, one is frequently reminded of the excellent counsel given by Polonius to his son Laertes. The diction is nervous and strong, with a refined purity that is impossible without high culture; the matter has everywhere running through it a rich vein of common sense and accurate knowledge of the world—not the ideal world of the man that dreams and theorizes, but the real world of the man of action.

We cannot refrain from quoting some thoughts relative to the great work in which we are ourselves engaged—that of educating the craftsman, the producer upon whose brain and brawn the weal and progress of the world so greatly depend.

Speaking of the insistent needs of the age, he argues for manual training:

"The demand for skilled workmen in all departments of industry is rapidly increasing. The result is beneficial in a marked degree. Thought and action are coming into a close relation. Every product of the hand which expresses the conception of the brain adds something to the power of the worker. Not alone the painter or the sculptor, but the machinist in our shops, the workman in our mills, every man whose employment requires some degree of manual dexterity, is placed in an attitude conducive to mental growth."

Again, he says: "The American people are a thinking people. The dinner-pail brigade in our cities, the men on our farms, are carrying the brains of the nation. In nothing is the progressive spirit of the age more manifest than in the management of our school system. And yet we cannot deny that there is here a feeling of unrest, a growing determination to effect radical changes in some directions. * * * * Manual training is knocking loudly at the schoolhouse door. To some of us it may prove an unwelcome visitor. Its tendency is to uproot old traditions, to unseat old prejudices, to tear down old idols that we long have worshiped, and to institute a new order of affairs. I do not believe that the public school has fulfilled its mission. My confidence in its usefulness was never greater than it is today, but I cannot banish the question from my mind whether it is not possible so to modify its curriculum, so to enlarge its sphere, as to put it into closer touch with the activities of life."

To the educators among his audience he says:

"We need your aid in sifting the practical from the visionary, the real from the false, to the end that we may add to the curriculum of our schools whatever tends to strengthen the intellect, train the hand, or enlighten the heart."

Thus the learned author shows himself to have been one of those educational pioneers that realized the twinship of the school and the workshop, of science and handicraft. We hope that his wise words may be helpful to many readers.

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ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*
2. *Only questions of general interest to our readers will be answered.*
3. *No questions will be answered by mail.*
4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*
5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*
6. *Reference to inquiries previously answered should give date of issue and number of question.*
7. *Questions cannot be answered in the issue of the month immediately following their receipt.*
8. *Any book not out of print and for sale by regular dealers may be ordered through the magazine.*
9. *We will not undertake to calculate windings of dynamos and motors, as this involves considerable work and is seldom justified.*

Our attention has been called to errors in the Answer to Inquiry No. 179, in the April issue. The errors committed consist in introducing into the formula for I the diameters instead of the radii, and the substitution of an addition sign by a multiplication sign. The correct solution of the problem is as follows:

$$I = \frac{W}{g} \times \frac{R^2 + R_1^2}{2} = \frac{1,280}{32.16} \times \frac{\frac{1}{4} + \frac{1}{144}}{2} = \frac{640 \times 6,001}{32.16 \times 576}.$$

Substituting this value in formula (*a*), we get

$$P = \frac{250\ \pi \times 640 \times 6,001}{150 \times \frac{1}{2} \times t \times 32.16 \times 576} = 1,628.38\ \frac{1}{t},$$

or with $t = .06$ sec.; $P = 27,140$ lb., nearly.

***

(249) A horse is tied to the end of a rope 100 ft. long, the other end being fastened to the corner of a barn 25 ft. square. How many square feet of ground can the horse graze over? J. M. H., Hermitage, Pa.

ANS.—The method of finding the area grazed over can be found in the answer to a similar question that was published in Answers to Inquiries, No. 77, in the March, 1898, "Home Study Magazine."

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(250) Please publish a method of dividing the circumference of a circle into any number of equal parts. J. B., New York, N. Y.

ANS.—There is no general geometric method. Either use your spacing dividers or your protractor.

***

(251) (*a*) How many feet of German silver wire will it take to cut down 10 volts to 1 volt? I intend to use No. 18 B. & S. wire and coil it into spring form for a resistance box to use in connection with electroplating. (*b*) How many feet will it take to cut down 1 volt to 0? W. G. B., Muscatine, Iowa.

ANS.—(*a* and *b*) Your inquiries are indefinite and cannot be answered with the information you have given. The amount by which a resistance will cut down the voltage depends on the current flowing through the resistance. The voltage taken up by the resistance is found by multiplying the resistance in ohms by the current in amperes. No. 18 B. & S. German silver wire containing 18% nickel has a resistance of .118 ohm per foot. If you wish to cut down the voltage 9 volts when a current of, say, 2 amperes is flowing, the resistance required would be $\frac{9}{2} = 4.5$ ohms, and this would require $\frac{4.5}{.118} = 38.1$ ft. With a larger current, the amount of resistance would be less. The best way to cut the voltage applied to the electroplating bath down to zero is to open the circuit.

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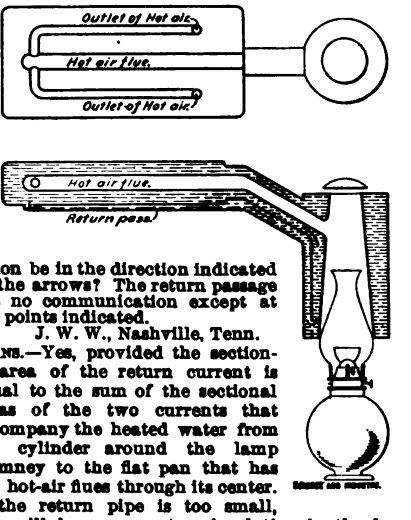
(252) I would like to know whether I can get free circulation in the hot-water incubator-tank construction as per accompanying sketch. Will circulation be in the direction indicated by the arrows? The return passage has no communication except at the points indicated.



J. W. W., Nashville, Tenn.

ANS.—Yes, provided the sectional area of the return current is equal to the sum of the sectional areas of the two currents that accompany the heated water from the cylinder around the lamp chimney to the flat pan that has the hot-air flues through its center. If the return pipe is too small, you will have a counter circulation in the lower opening of what you now show as the flow pipe.

***

(253) What books would you advise me to study in order that I may gain a fair knowledge of descriptive geometry? B. T., Denver, Col.

ANS.—Warren's "Manual of Elementary Projection Drawing," price $1.50, is a good book for beginners; while MacCord's "Descriptive Geometry," price $3.00, or Davies's "Descriptive Geometry," price $2.00, are better adapted to the wants of more advanced students. Any of these books may be obtained from The Technical Supply Co., Scranton, Pa.

***

(254) In the Wood arc dynamo, the number of armature coils short-circuited between the 2 brushes of each denomination increases as the brushes are moved to the position of maximum voltage, and decreases when they are moved to the position of minimum voltage. How does this agree with Mr. Wood's theory that, at full load, commutation takes place in a stronger field that at light load? With full load, a smaller number of armature coils will provide counter E. M. F. sufficient to prevent sparking, and, with full load, the commutation taking place in a weaker field, it is necessary to short-circuit a larger number of coils to provide the requisite E. M. F. E. E. T., Joliet, Ill.

ANS.—The field is stronger because when the brushes

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are moved to the full-load position, the back ampere-turns of the armature are less and the armature does not have such a demagnetizing effect on the field. The belt of coils short-circuited by the brushes is also greater at full load, and, since these coils are cut out, the back magnetizing action of the armature is thus further reduced, and the consequence is that the field in which commutation occurs is stronger at full load than at light load.

***

(255) Please explain the principle of the Greenwood universal planer chuck, which is said to be adapted for planing locomotive links and other parts of circular form. J. R., Cowanesque, Pa.

ANS.—In the chuck named the work is held in a vise that is hinged in the body proper of the chuck

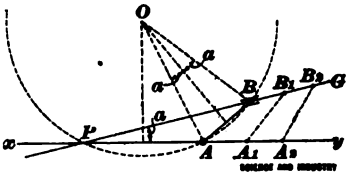

FIG. 1

in such a manner that it can swing in a vertical plane parallel to the motion of the planer bed. This swinging vise carries a swiveled crosshead that slides on a guide bar fixed to the stationary frame of the planer, at an inclination to the bed. Fig. 1 shows the arrangement in form of a diagram. *A B* represents the vise holding the work swiveled at *A*, which latter point moves with the planer bed in the direction *x y*; point *B*, by virtue of the crosshead, slides on the guide *P G* fixed to the frame. In its motion the vise *A B* will successively assume positions such as shown at $A_1 B_1$, $A_2 B_2$, relative to the stationary frame of the machine, including the guide, which is part of it. The same *relative* motion between vise *A B* and the machine frame would result if we considered the former stationary and the whole machine in motion in such a manner that the two lines *x y* and *B G* forming the fixed angle *a* with one another would always pass through the fixed points *A* and *B*, respectively. The point *P* of the machine would then describe a circle, of

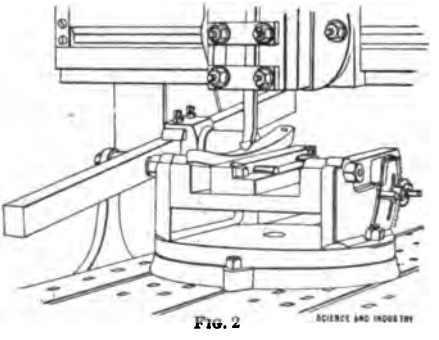

FIG. 2

which *A B* is a chord, and whose radius is equal to $\frac{A B}{2 \sin a}$, which follows from the geometrical theorem that an inscribed angle is equal to one-half the angle at the center intercepting the same arc. Point *P* is the only point in the machine that has a circular path, considering the vise *A B* stationary, or with respect to which the vise and the work it holds will have a circular motion while sliding on *P G* and *x y*. Hence, the chuck is placed on the planer bed in such a position that the cutting point of the tool will, as near as possible, coincide with this point. Fig. 2 is an outline perspective view of the Greenwood chuck. It can be used without the guide, as an ordinary chuck.

***

(256) (*a*) A bullet is fired from a rifle vertically upwards. When it returns to the earth, will its velocity be the same as when it left the gun? (*b*) Will the distance traveled be less when the bullet is fired horizontally than when it is fired vertically? G. B., Galt, Ontario, Can.

ANS.—(*a*) As soon as the bullet leaves the rifle, gravity acts on it to keep it to the earth, and its velocity decreases until the bullet momentarily stops, when it begins to fall; the velocity then increases until the bullet strikes the earth. Since the height through which the bullet falls is the same as that through which it ascended, the velocity on striking would be the same as that which the bullet had when leaving the rifle, if there were no resistance due to the air. (*b*) Neglecting the air resistance and assuming the velocity of the bullet on leaving the rifle to be 1,200 ft. per second, the height to which it would rise would be $h = \frac{v^2}{2g} = \frac{1{,}200^2}{2 \times 32.16} = 22{,}388$ ft. This is a far greater distance than any rifle could carry if held horizontally and fired by a man standing on the ground.

***

(257) (*a*) What is the meaning of the term "city base of levels"? Is it a term used with reference to the high-water mark of a city on the coast? (*b*) Kindly give me the name of a book treating on the design of the Joy valve gear; or, if it is not too much trouble, please explain it in your columns. W. C. C., Cleveland, Ohio.

ANS.—(*a*) A city base of levels, or city datum, is an imaginary horizontal surface arbitrarily assumed at a certain distance below some permanent object. The elevation of this imaginary surface is assumed to be zero, and in running levels the elevations of all points in the city are referred to this imaginary surface, or city base; that is, the elevations are recorded by their distances above the city base. The city base is always taken below the lowest point in the city. It is sometimes assumed at, say, 100, 200, or 500 ft. below some permanent point, such as a point on the masonry of a large building; or, if the city is near tidewater, it is commonly taken at the elevation of mean tide. The latter method is being gradually extended inland as fast as connecting levels can be established. (*b*) We do not know of any book that gives information regarding the design of the Joy valve gear, and it is impracticable for us to try to explain it in these columns. You can probably get the information you need by writing to the inventor and patentee, David Joy, M. I. C. E., London, Eng.

***

(258) (*a*) What is meant by a shunt-wound armature? What is meant by (*b*) shunt fields? (*c*) exciting the fields? (*d*) What is the object of an exciter? (*e*) In starting a street car, do both motors propel the car when the controller is on the first notch? J. R. PAUL KRUGER, Transvaal, Jamaica, B. W. I.

ANS.—(*a*) There is no such thing as a shunt-wound armature so far as we are aware. You probably refer to an armature used for a shunt-wound dynamo. The same armature might, however, be used in either a shunt-wound or series-wound field. (*b*) A shunt field is one that is excited by a winding connected in parallel with the armature. In this type of winding only a small part of the current passes through the field coils, and it is so called to denote the fact that a part of the current is "switched off,"

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or "shunted," around the field coils, to distinguish it from series field when the whole current flows through the field coils. (*c*) By exciting the field is meant the process of setting up magnetism through the armature of a dynamo by sending a current around the magnetizing coils wound on the field-magnet frame. (*d*) An exciter is a small direct-current dynamo used to furnish the current for exciting the fields. Exciters are used only with alternators, since direct-current machines furnish their own current for exciting the fields. (*e*) When the controller is on the first notch, both motors are in series with the whole of the resistance, hence the current that flows through one motor also flows through the other and both motors propel the car.

***

(259) (*a*) Do you know of any good arrangement for storing boiler plates, such as might be used in a regular boiler shop, either in the shape of a rack or stand? (*b*) What method have they of handling these plates where they have stands?

J. S. C., Montreal, Can.

ANS.—(*a* and *b*) As the arrangement of rack and method of handling the plates depend on the location of the storeroom, the amount of material handled, the space and facilities available, the amount of money you wish to spend, etc., we would advise you to go to different boiler shops and see how other people do it. Select all the good points you discover, and then, using your ingenuity, design a rack suitable for your shop. By this means you will get a more suitable design than we, not knowing anything of the modifying conditions, could suggest.

***

(260) (*a*) Would it be possible to get a battery or batteries powerful enough to supply current for operating a 16 c. p. lamp? (*b*) What would such a battery cost? (*c*) Would Leclanché cells answer the purpose? (*d*) Would it be necessary to have a rheostat? I wish to use the lamp for reading purposes.

J. A. K., Marsville, Ont., Can.

ANS.—(*a*) It would be possible to operate a 16 c. p. lamp by means of primary batteries, but it cannot be recommended as a very cheap or convenient means of securing electric light. (*b*) A primary battery large enough to operate a 16 c. p. lamp for, say, 50 hours, without recharging, would cost in the neighborhood of $40.00. The number and size of cells required would depend altogether on the style of lamp. This estimate is based on the use of Edison-Lalande cells, which are about as satisfactory a form of primary cell as can be obtained for this kind of work. (*c*) Leclanché cells would not be suitable for this work, as they are not capable of furnishing a steady current. They are only intended for use on circuits where current is required for short intervals. (*d*) It should not be necessary to use a rheostat if the cells are connected up so as to give the pressure required by the lamp.

***

(261) I have a dynamo with an 11″ pulley, making 1,450 R. P. M., belted to a 4′ 5″ pulley on a water-wheel making 261 R. P. M. The power is only capable of generating 160 amperes. If I put in a slow-speed dynamo, say of 600 R. P. M., what will be the size of the pulley on the new machine and how many 16 c. p. lamps of 54 watts at 110 volts will my power operate? By increasing the pulley on the dynamo, I will gain power, but I do not know how much.

G. W. T., Crested Butte, Col.

ANS.—You are mistaken about the gain in power. Changing the pulley on the dynamo will not enable you to operate any more lamps, and a slow-speed dynamo will not operate any more lamps with the power at your disposal than the high-speed machine, unless, perhaps, the slow-speed machine should happen to have a little higher efficiency than the other. The gain on this account would, at best, be but slight. You must have a certain amount of power at the waterwheel for every lamp operated, and if you have not enough power at the waterwheel, you will not be able to operate any more lamps, no matter what combination of pulleys or what type of dynamo you use. For a machine at 600 R. P. M., you would need to use a pulley on the dynamo about 23 in. in diameter.

***

(262) (*a*) Suppose we have two motors, one a shunt-wound, and the other a series-wound, machine; also, suppose the current for which they are wound, their current capacity, and their speed are not known, how could you find what voltage and current they are suited for? (*b*) How can I fix a negative so as to use it as a lantern slide?

R. L. D., Washington, D. C.

ANS.—(*a*) You have given us very scant information on which to base any answer to this question. We presume that both machines are designed for direct current. In the case of the shunt machine, connect the shunt field in series with a lamp resistance to a source of current, and see what current can be sent through it continuously without overheating. The voltage across the terminals of the field under these conditions will be somewhere near the voltage for which the machine was designed. To determine the current capacity, operate the machine on this voltage and gradually increase the load until the machine is taking as much as it will stand without overheating the armature. You may also obtain a rough idea as to the current capacity by examining the size of wire on the armature. The current in the armature wire should not exceed 1 ampere for every 500 circular mils cross-sectional area. If it is a two-pole machine, there will be two paths through the armature; hence, you can have 2 amperes in the outside circuit for every 500 circular mils of armature conductor. There should be about 800 or 900 circular mils for each ampere in the field coils; hence, you can determine what the approximate field current should be, and this, multiplied by the field resistance, will give the voltage. In the case of a series machine, you can determine the approximate current capacity by allowing 800 or 900 circular mils per ampere for the series field winding. The machine may be run as a dynamo under load, and the voltage across its terminals measured when it is delivering the estimated current and running at a speed suitable for the machine. The peripheral speed of the armature should not exceed 3,000 ft. per minute, and besides you should be able to tell from the size and general construction of the machine as to the speed it will be safe to run at. (*b*) Negatives cannot be used directly as lantern slides, but slides may be printed from the negative in the ordinary way, as for paper. To make a lantern slide, a small dry plate 3¼″ × 4″ is placed in contact with the negative in the printing frame and exposed to artificial light from 5 to 20 seconds, according to the density of the negative, developed in the usual manner, and fixed in hyposulphite of soda. This gives a positive on glass that may be projected upon the screen with the magic lantern. If the negative is larger than the standard lantern-slide plate, it is necessary to reduce it in order to make the positive. This may be accomplished by placing the negative against a window in such a manner that the light from a clear, unobstructed sky passes through it. Then, setting the camera up in front of it, it is photographed on a lantern-slide plate placed within the plate-holder of the camera. Complete information on the preparation of lantern slides will be found in "Photo Miniature," No. 9, price 25 cents; for sale by The Technical Supply Co., Scranton, Pa.

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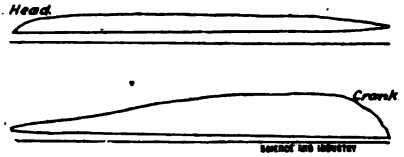
(263) Please give me your opinion of the accompanying indicator cards, and tell me how much coal can be saved by setting the valves properly. The cards were taken from an old Fishkill slide-valve engine with a Meyer positive cut-off. Cylinder, 14″ × 30″; R. P. M., 10; boiler pressure, 60 lb. gauge; scale of spring, 30. G. E. W., Catskill, N. Y.

ANS.—If the cards are a correct indication of the action of the engine, they show about as bad a state of affairs as it is possible to imagine. A measurement of the diagrams shows a mean effective pressure for the head-end of less than 4½ lb. per sq. in. and, for the crank-end, the mean effective pressure is but little more than 9 lb. The indicated horsepower shown by the cards is only 11 H. P. If the engine is doing no more work than is indicated by



these cards, no modification of the valve setting will make it reasonably economical in its use of steam; the best thing to do is to get a new engine of a size suitable for the work. It is possible that the cards do not give a correct indication of the conditions; the indicator or its connections may have been imperfect, thus producing diagrams that are not a fair representation of the actual conditions.

***

(264) (*a*) Are lightning arresters now used to any great extent on telegraph lines, and are they considered effective in preventing the burning out of telegraph instruments? (*b*) What are the chief essentials in bituminous and lignite coals for best results in burning in a locomotive? What percentage of moisture, volatile matter, fixed carbon, and ash should a good steaming coal have? (*c*) How can you tell whether a coal is bituminous or lignite?

F. J. A., Edgemont, S. Dak.

ANS.—(*a*) Yes; they are used and are effective. Of course, an instrument may now and then be damaged, but a good type of arrester practically prevents burn-outs. (*b*) The question is not clearly put. The essential *parts* or ingredients are carbon and hydrogen; the essential *conditions* are, as in the combustion of any other coal, that there shall be a sufficient supply of air, thoroughly mixed with the coal and gases, at a sufficiently high temperature. A coal that contains 85% of carbon, 12% of volatile matter, and 3% of ash is a good steaming coal. The best coal for steaming purposes that we are acquainted with is that used in England for steamship trials. An analysis of a specimen of this gave the following result: 90.27% carbon, 4.89% hydrogen, .69% sulphur, .49% nitrogen, and 4.16% oxygen. (*c*) Lignite is a dull-looking coal, and more easily broken up. It contains much less carbon than does bituminous coal.

***

(265) What causes the coppers in the short end of a gravity quadruplex battery to become corroded at the top so much as to cause connections to break? The short end is to line when both keys are closed, working to a dynamo current at the other terminal, voltages so adjusted as to give no current on main-line side with all four keys closed. The above effect is noticed about 3 weeks after the battery is entirely renewed. R. O. M., Bloomington, Ill.

ANS.—In the first place, the short end of the battery is worked much harder than the long end, and if the same trouble affected both, it would be shown much quicker in the short-end cells. Are you careful to place the point where the copper wire joins the copper plate as near the bottom of the cell as possible, being careful, also, to see that the wire is covered with its insulation down close to that point? Without seeing it, we would say that it was due to local action caused by impure, improper, or defective materials, or to improper setting up of the cells.

***

(266) (*a*) Will you please inform me how to prepare a battery? All I have is some white powder. (*b*) How do you connect the battery to a motor to run it? J. C., Carthage, Mo.

ANS.—(*a*) We do not know what the white powder is that you refer to, hence cannot give instructions for making a battery. If you wish to make a battery for running a small motor, we can recommend the one described in SCIENCE AND INDUSTRY, April, 1900. Answers to Inquiries, No. 144. (*b*) Connect the terminals of the battery to the terminals of the motor.

***

(267) (*a*) Which water motor will develop the most power, one with a 12″ or one with a 16″ wheel, both working under the same conditions, and what would account for any difference? (*b*) How much power will a water motor develop with 4″ supply pipe and 2″ discharge nozzle, under a head of 30 ft.? (*c*) What size of wheel would give best results under the conditions named in question (*b*)?

J. B. R., Norwich, Conn.

ANS.—(*a*) It is probable that the difference would be scarcely perceptible, although under some conditions the larger wheel might deliver a little more power than the other. (*b*) Without knowing the length of the 4″ pipe, it is impossible to calculate the amount of power that could be obtained. Considerable energy will be absorbed in overcoming the frictional resistances to flow through a pipe of this size; if the pipe is very long or crooked, the frictional losses might be so great that but little would be available at the nozzle. (*c*) The best size of wheel depends on the work it is to do, as well as on the head and the quantity of water used. Your statement of the conditions is too meager to enable us to make an estimate.

***

(268) I send you blueprint of a steam shovel that is mounted on two trucks. The front truck can be moved backwards or forwards by jacking up the front end of the platform, and has on it a turntable that will allow the shovel to be turned around when the center of the table falls under the center of gravity of the shovel. The engine has an 8″ × 11″ cylinder, and carries 100 lb. steam pressure. The ratio of the gear on the crank-shaft to the gear on the drum is 1:5, and diameter of drum is 16 in. (*a*) How can I find the center of gravity of the shovel? (*b*) What is the maximum pull the engine can transmit through the chain to the dipper?

W. H. W., Toledo, Ohio.

ANS.—(*a*) To *calculate* the center of gravity, apply the method of moments described under the heading "Center of Gravity" in the "Mechanics' Pocket Memoranda." It may be determined experimentally with greater accuracy, or at least with greater certainty of obtaining the correct result, by placing the front truck on a pair of railway scales and weighing the machine for different positions of the front truck. The platform of the shovel should be level whenever a reading is taken. That position of the truck that gives the highest reading on the scales is the position of the truck when the shovel is balanced; that is, when the center of the truck is under the center of gravity of the shovel. When taking the reading, no part of the rear truck must touch the scales. (*b*) Neglecting all frictional and other losses, the greatest force the engine can transmit to the chain is (neglecting the ratio of the crank to the connecting-rod) $8^2 \times .7854 \times 100 \times 4\frac{1}{2} \times \frac{1}{5} = 17{,}278.8$ lb., say 17,280 lb. Assuming that there is a loss of 20% due to friction and other causes, the maximum available

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force is 17,280 × .80 = 13,824 lb. The number 11 is the diameter of the crankpin circle, which is the same as the stroke.

***

(269) In making a new jacket for a locomotive, is there any way of laying out the sweep of the sand and steam dome without first making and fitting a templet, which means lost time? The diameter of the steam dome is 40 in., and the diameter of boiler is 54 in. J. T., Ottawa, Kan.

ANS.—In Fig. 1, *a b c d* represents the dome, and *b e c g* the barrel of the boiler. On *a d*, as diameter, describe the semicircle *a f d*, and divide the quadrant *a f* into a convenient number of equal parts, say 6, at *1, 2, 3, 4,* and *5*. From points *1, 2, . . . f*, drop perpendiculars cutting *a h* in points *1′, 2′, . . . h*, and the arc *b g* of the boiler in points *6, 7, 8, 9, 10,* and *g*, respectively. Next, lay out *A B* to represent the jacket, and draw the center line *Co C*, Fig. 2. From *o*, etc., lay off *o–1, 1–2, 2–3, . . . 5–6*, equal, respectively, to the arcs *g–10, 10–9, . . . 6–b*; and then draw the perpendiculars *o–7, 1–8, . . . 5–12* equal, respectively, to *h–f*,

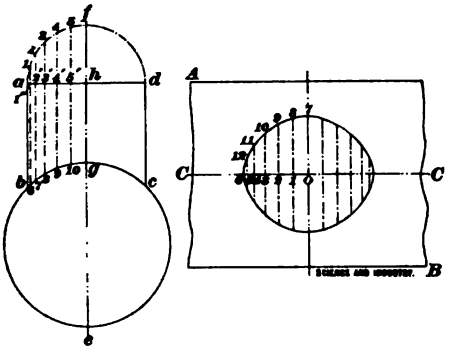

FIG. 1 FIG. 2

5′–5, . . . 1′–1. Draw a curve through the points *7, 8, 9, . . . 12, 6*. This will give one quarter of the outline of hole required in the jacket. The remainder is found in the same way. When the sheet *A B* is bent into a circle of the same diameter as *b e c g*, the projection of this hole will be a circle of diameter *a d*.

***

(270) (*a*) Are there any books containing formulas for calculating the pressures in, and the thickness of, steel required for stand pipes and round and square steel tanks filled with water? (*b*) What is the formula for calculating the proper diameter of a bell-bottom stack of a given size, so as to obtain the proper slope of the bell? (*c*) How are photographs of drawings made, and is it possible to make them with a 4″ × 5″ adjustable focus camera? (*d*) Name a cheap and good book on strength of materials suitable for a student. (*e*) Please name two good books treating exclusively on cuts, templets, and developments. (*f*) Please show me how to develop the sheets for the joint shown in the accompanying sketch. R. C. W., Coatesville, Pa.

ANS.—(*a*) The general principles on which the relations between the sizes of tanks and pressures in tanks are based, are found in all good books on elementary mechanics, and the general methods of estimating the strength and thickness of plates required to withstand the pressures are found in books on the strength of materials. Without a good knowledge of these principles it will be difficult to do successful work in designing such structures. "Kent's Mechanical Engineer's Pocketbook," price $5.00, and "The Theory of Modern Framed Structures," by Messrs. Johnson, Bryan, and Turneaure, price $10.00, are the two books that contain the most practical information on the design of stand pipes that we know of. They may be obtained from The Technical Supply Co., Scranton, Pa. (*b*) So far as we know, there is no definite formula for this purpose. The diameter of the base of a steel stack is made great enough to secure sufficient strength in the bottom joints and in the foundation bolts to resist the overturning effect of the heaviest wind pressure to which the stack is likely to be subjected. The amount of spread to be given the base in any given case must be determined from a consideration of the force of the wind, the diameter and height of the stack, and the conditions under which the stack is to be built. (*c*) An ordinary adjustable focus camera of any size can be used for making photographs of drawings. However, if the size is reduced very greatly, the scale of the photograph may be so small that it will not be satisfactory. The drawing should be held flat, in a vertical position, in a good light, and the camera placed at such a distance from it that when the proper focus is obtained the image will be in the desired position on the plate. The exposure, development, and printing are all carried out in the same manner as for ordinary photographic work. (*d*) "The Strength of Materials," by Mansfield Merriman, price $1.00, is a useful book for beginners that have a limited knowledge of mathematics. A more advanced work is "A Textbook on Mechanics of Materials," by the same author; price $4.00. Some knowledge of higher mathematics, including the calculus, is required to understand all parts of this book. Either of these books may be obtained from The Technical Supply Co., Scranton, Pa. (*e*) "Metal Plate Work," by C. T. Millis, price $3.50; and "Boilermaking for Boilermakers," by W. H. Ford, price $1.00, may be obtained from The Technical Supply Co., Scranton, Pa. (*f*) This development is accomplished by triangulation; a satisfactory description of this process is impossible in the limited space afforded by these columns.

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(271) I have a fan motor for 110 volts; the armature has 16 slots, each slot containing 126 conductors, No. 30 B. & S. The field coils each contain 900 turns No. 28 B. & S. (*a*) What size of wire and how many turns should be used on the field and armature to adapt the motor to a 6-volt battery current? (*b*) How many cells will it take to run this motor if each cell contains 6 carbon and 5 zinc plates 3″ × 4″ × $\frac{1}{8}$″ immersed 3½″ in the liquid? (*c*) How shall I make the bichromate-of-potash solution? (*d*) I wish to use a wooden trough for making up the cells; how can I make the insulation paint or compound for same? (*e*) Where can I get a sample copy of each of the following papers: "American Chemical Journal," "Chemical News," "American Chemist," "Journal of the American Chemical Society"? J. L., Dayton, Ohio.

ANS.—(*a*) Use 8 conductors of No. 18 B. & S. per slot on the armature, and about 50 turns No. 16 B. & S. on each field. (*b*) You would likely need at least 12 cells in order to run the motor for any length of time. These would be connected up three in series, and the four groups thus formed connected in parallel. (*c*) Dissolve 3 parts of potassium bichromate in 18 parts of water to which 4 parts of sulphuric acid has been previously added; all parts by weight. The sulphuric acid should be poured slowly into the water when mixing. Do not, on any account, pour the water into the acid. (*d*) We would not advise you to attempt making an insulating paint; it will be cheaper and more satisfactory to buy it. Lead the joints well and apply three or four good coats of P. & B. paint. This paint can be obtained from almost any electrical supply house. (*e*) From the publishers, whose addresses follow: "American Chemical Journal," Baltimore, Md.; "Journal of the American Chemical Society," 44

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First Ave., New York City; "Chemical News," London, Eng. We do not know where the "American Chemist" is published.

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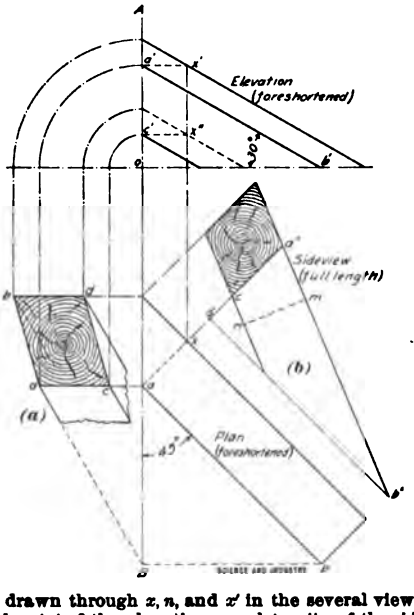
(272) Please illustrate a graphical method of finding the correct end view of an obliquely inclined timber; for example, an 8" × 8" hip rafter, intercepted by a vertical plane coinciding with one edge of the ridge board. ALPHA, St. Augustine, Fla.

ANS.—For convenience of illustration, the angle shown in the plan of the accompanying sketch is one of 45°, and that assumed for the elevation is 30°. This problem is most easily worked out by first fixing in the different views the position of any one of the four edges of the timber. Let *A B* represent the vertical plane, and *a b* of the plan and *a' b'* of the elevation, one edge of the timber, each drawn at its proper angle with the vertical plane. The width of the timber may be laid off on the plan at *a x*, and since it is known that *a x* is horisontal, the point *x'* may be represented in the elevation in the manner shown. In order that the thickness of the timber may be represented, the side view shown at (*b*) may be drawn; in this view, the distance *a'' o'* is transferred in the dividers from the elevation, where it is represented as *a' o*. The thickness of the timber may now be laid off as *m n*, and parallels to the edge



a b drawn through *x*, *n*, and *x'* in the several views. Make *a' c'* of the elevation equal to *a'' c* of the side view, and fix the point *x''* as shown. The remaining edges of the timber may now be represented in the elevation. From their intersections with the plane *A B* projectors are described from the point *o* as a center; these projectors are continued parallel to *A B*, and intersected at (*a*) by projectors drawn from the plan. The desired full view of the intercepted surface of the timber is then outlined, as shown at (*a*).

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(273) (*a*) Please give me the formulas for calculating the strength and efficiency of the following riveted joints: (1) Butt joints with single- and double-welt plates; (2) single-welt joints, both single- and double-riveted; (3) double-welt joints, with double, triple, and quadruple rows of rivets. (*b*) What is the allowable tensile strength of copper used in locomotive fireboxes? (*c*) What is the thickness and strength of brass tubes used for flues? (*d*) If the formulas differ from those used for steel, kindly state them. (*e*) Please explain the methods used in riveting copper plates, and the methods of determining size and pitch of rivets. M. S. T., Lima, Ohio.

ANS.—(*a*) It is impossible to give simple formulas for all of these cases, and a discussion of the subject that would be of any value to you would require more space than can be given it in these columns. Considerable information on the subject can be obtained from "Elements of Machine Design," by W. C. Unwin, which may be obtained from The Technical Supply Co., Scranton, Pa., price $2.00. Most books on steam boilers also contain some information on the subject of riveted joints. (*b*, *c*, *d*, *e*) The copper used for fireboxes is generally required to have a tensile strength of not less than 14 tons (31,360 lb.) per sq. in., an elongation of 45% in 8 in., and a contraction of area of 50 to 60%. The copper used for the screw stays must show about the same strength and an elongation and contraction of area of 55 to 60%. Both the plates and rods must undergo cold-bending tests. Iron rivets are used in drilled holes. The other items asked for depend on pressure and thickness of plates. For an engine carrying 175 lb. boiler pressure, the following dimensions would be about right for the thickness of firebox sheets: Tube-sheet, ⅞ in. where tubes are, and ½ in. below (opposite throat sheets); crown sheets and side sheets, ½ in.; back sheet, ⅜ in. (some designers ignore the greater wear and attack of flames on certain of the sheets, and would make crown, back, and side sheets all ⅜ in.); ¾" iron rivets, 2¼" pitch. Use 1" stays; 12 threads, pitched 4" centers; 1¾" O. D. brass tubes; No. 11 B. W. G. at firebox end, tapering to No. 13 at front end.

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(274) Will you kindly recommend a good book on telephotographic lenses? M. H., Chicago, Ill.

ANS.—"Modern Lenses in Photo Miniature," No. 1; price 25 cents. "Photographic Optics," by R. S. Cole; price $2.50. "Telephotography," by Thomas Dallymeyer; price $4.00. These books can be ordered through The Technical Supply Co., Scranton, Pa.

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(275) How can I solder aluminum?

G. A. R., Brooklyn, N. Y.

ANS.—There have been a number of different solders brought out for aluminum that are claimed to be successful. One of these is given in SCIENCE AND INDUSTRY, November, 1899, Answers to Inquiries, No. 294, but we cannot vouch for its efficacy.

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(276) Please tell me how I can solder a piece of brass to a piece of aluminum.

L. J. E., Chicago, Ill.

ANS.—See answer to No. 275 in this issue.

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(277) (*a*) Please give me some of the principal dimensions of a two-cycle gasoline motor, to run a boat carrying 5 or 6 people at a speed of 4 or 5 miles an hour. (*b*) Is it practical to admit the gas at the bottom of the stroke, by uncovering the ports by the piston, and so have a practically valveless motor? (*c*) In a motor of this size, would a water-jacket around the cylinder be a necessity? (*d*) How, and in what proportion, is the gas mixed with the air? (*e*) How can I index and preserve scraps that cannot be pasted in a scrapbook on account of desiring to read both sides?

E. R. R., Manchester, N. H.

ANS.—(*a*) The size of a motor required will depend considerably on the construction of the boat. A motor rated at 1 horsepower would probably be sufficiently large. Such a motor would have a

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cylinder about 3 in. in diameter with a stroke of 3 in., the number of revolutions being about 400 per minute. (*b*) The method of admitting gas to the cylinder through ports uncovered by the piston is described in the "Home Study Magazine," of February, 1898. You will also find information regarding this type of motor in nearly any textbook on the gas and gasoline engine. One of the latest books of this kind, that gives information regarding small motors of the type about which you inquire, is the "Gas Engine Handbook," by E. W. Roberts; price $1.00. This book may be obtained from The Technical Supply Co., Scranton, Pa. (*c*) If the motor can be set so that a strong current of air can be made to act on the cylinder, the cylinder may be cooled by means of ribs cast on it without the necessity of using a water-jacket. A water-jacket is, however, to be recommended for marine purposes, since water can be so easily secured, and the cylinder is cooled much more satisfactorily by water than by a current of air. (*d*) Various methods of mixing the gas and air are used. For a description of some of these methods, we refer you to the copy of the "Home Study Magazine" mentioned above, and also to the "Gas Engine Handbook." In the April number of SCIENCE AND INDUSTRY you will find a brief description of a small gas engine, drawings for which may be obtained from Mr. G. H. Johnston, Sparrows Point, Md. (*e*) Several methods are described in the article on "Scrapbooks" in the November, 1899, issue.

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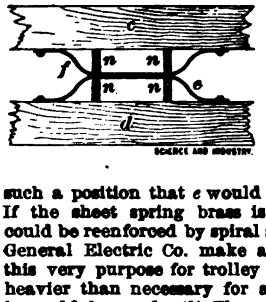
(278) (*a*) How can I arrange a single telephone line, running across a drawbridge, so that the line will automatically open and close when the draw is opened and closed? I do not want to go to the expense of putting down a cable. (*b*) Kindly mention several good telephone magazines.

A. H. S., Amherst, N. S., Can.

ANS.—(*a*) It could be arranged as shown in the accompanying figure, in which *c* and *d* are cross-arms or wood supports to which the springs *e* and *f*, made of stiff spring brass several inches wide, are fastened—spring *e* to *d*, and spring *f* to *c*. The piece *c* would be stationary, and *d* fastened to the drawbridge in such a position that *e* would press firmly against *f*. If the sheet spring brass is not stiff enough, it could be reenforced by spiral springs *n*, *n*, etc. The General Electric Co. make a drawbridge frog for this very purpose for trolley lines. Although it is heavier than necessary for a telephone line, still it could be used. (*b*) The only distinctively telephone paper we know of is the "Telephone Magazine," Chicago, Ill.



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(279) Please answer the following questions: (*a*) In a water-tube boiler, what should be the ratio of the sectional area of the tubes to their length? (*b*) What should be the depth and the area of the surface of the water in the separating chamber or drum connected to the tubes, per square foot of water heating surface, to insure that the steam will leave the water quietly? (*c*) Is it good practice to leave water standing in a boiler when it is used occasionally, say one day in each week, there being no danger of freezing and the water being practically pure?

N. M. B., Norwich, Conn.

ANS.—(*a*) There is no definite ratio; it depends entirely on the design of the boiler. (*b*) This depends very largely on the design; an examination of various designs will show a great difference in the ratios used. Much depends on the position in which the tubes are connected to the separating chamber. In a boiler of the Babcock & Wilcox type the connection is made at one end of a long narrow drum, and but a small part of the surface of the water is really effective as a separating surface. In a boiler of the Cahall type the connections of the tubes are evenly distributed over the under side of the drum, and the whole area is thus made of nearly the same efficiency. (*c*) Yes.

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(280) (*a*) What is the solution of the formula

$$i_t = \frac{E}{R}\left(1 - e^{-\frac{R}{L}t}\right),$$

where i_t = strength of current after the lapse of a short time t, say 8 seconds; E = electromotive force, say 10 volts; R = resistance of whole circuit, say 1 ohm; L = coefficient of self-induction, say 3.5 henrys; and e = number 2.7183 (base of the Naperian system of logarithms)? Also solve

$$\frac{R \times e^{\frac{R}{L}t}}{\left(e^{\frac{R}{L}t} - 1\right)}.$$

(*b*) How is the coefficient of self-induction found in continuous-current circuits?

J. B., Central Falls, R. I.

ANS.—(*a*) Substituting the above values, we have

$$i_t = \frac{10}{1}\left(1 - 2.7183^{-\frac{1}{3.5} \times 8}\right) = 10\left(1 - \frac{1}{2.7183^{2.285}}\right).$$

$$\text{Log}\,\frac{1}{(2.7183^{2.285})} = \log 1 - 2.285 \log 2.7183$$
$$= 0 - 2.285 \times .4343$$
$$= 0 - .9923 = \bar{1}.0077.$$

Hence, $\frac{1}{(2.7183^{2.285})} = .1018$, and $i_t = 10\,(1 - .1018) = 8.982$ amperes. Substituting in the second expression, we have $\frac{1 \times 2.7183^{2.285}}{2.7183^{2.285} - 1}$. From the previous example, $\log 2.7183^{2.285} = .9923$, and $2.7183^{2.285} = 9.825$; then we have $\frac{9.825}{8.825} = 1.113$, nearly. (*b*) If the current is continuous, there is no self-induced E. M. F. set up in the circuit, because there is no change in the magnetic field. The easiest way to measure the self-induction of a circuit is to take readings of the current and E. M. F. supplied to it from an alternator. Then, if R = resistance, L = coefficient of self-induction, E = E. M. F., c = current, and f = frequency (cycles per second), we will have

$$c = \frac{E}{\sqrt{R^2 + (2\pi f L)^2}},$$

from which L may be obtained. The coefficient of self-induction does not depend on the character of the current, but the induced E. M. F. does; i. e., the coefficient of self-induction of a given coil is a certain amount, depending on the shape of the coil, number of turns, etc., but the induced E. M. F. depends on the frequency and amount of current, as well as on the coefficient of self-induction.

***

(281) I wish to build a special high-pressure boiler with tight joints, for launch purposes. I would like to braze as well as rivet the joints, also braze the tubes to the heads. Would the brass or spelter be electropositive to the steel, and would the same cause corrosion? L. O. W., Tarrytown, N. Y.

ANS.—There would likely be electrolytic corrosion under the above circumstances. You should not braze the boiler anyway. There should be no difficulty in making the boiler tight by calking the joints and expanding the tubes in the heads.

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(282) (*a*) Please recommend a good book on inorganic chemistry—one that covers a great deal of ground and can be understood by one that wishes to learn something of the subject. (*b*) Name a good book on batteries—both primary and secondary.
H. N., Brooklyn, N. Y.

ANS.—(*a*) Ira Remsen's "Inorganic Chemistry," advanced course, American Science Series, price $2.80. (*b*) We are not acquainted with any good book that takes up both primary and secondary batteries in detail, but you will find that the two following books cover the ground: "Primary Batteries," by Carhart, price $1.50; "The Storage Battery," by Treadwell, price $1.75. Any of the above books may be obtained from The Technical Supply Co., Scranton, Pa.

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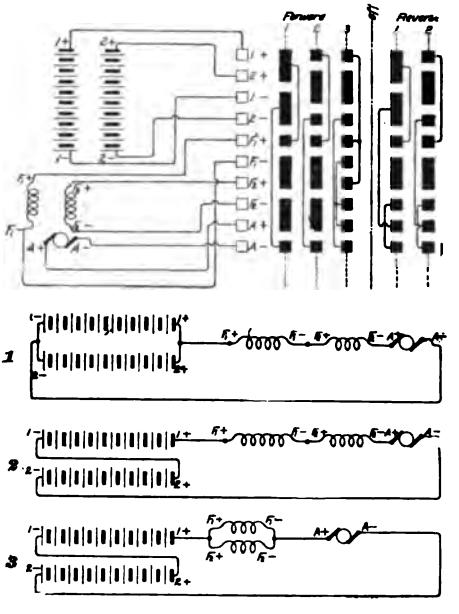
(283) (*a*) Please give a diagram of wiring for an automobile so as to give three speeds with a battery of twenty cells, with a method of reversing and regulating. (*b*) Give name and price of a book that covers the above completely, and the names and prices of books that fully describe the several automobiles.
H. M. H., Keller, W. Va.

ANS.—(*a*) It would take much more space than we can allow to go into a detailed description of the



wiring of an automobile. You have given no information whatever as to the type of motor you intend using, or whether you intend using a single motor or two motors. The accompanying diagram shows a developed controller that gives three forward speeds and two reverse speeds. We have shown it for a single motor with two field coils, which are connected in parallel for the high-speed combination. The 20 cells are placed in two groups of 10 each. On the first notch these two groups are in parallel, and the fields of the motor are in series. On the second notch the two groups are in series and the motor the same as before. On the third notch, the fields are in multiple. The two reverse notches are the same as the first two forward notches, except that the armature terminals are reversed. (*b*) Automobiles have not been in use long enough to bring out much literature on the subject, outside of current periodicals, such as "The Electrical World and Engineer," or "The Horseless Age." You might obtain considerable information by consulting files of these papers. A book that may contain the information you need has just been published. It is entitled "The Electric Automobile," by C. E. Woods; price $1.25.

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(284) (*a*) Kindly give me the following account in its proper posting: We work for Mr. D to the amount of $8.65; we receive from Mr D merchandise to the amount of $8.65. Now, at the end of the month, we pay our difference, and thus far have been setting it down as receiving $8.65 cash for work, and charging the whole $8.65. This does not seem correct to me, although it shows the whole transaction in the cash account. (*b*) Explain how black oxide of copper is made.
W. T. T., Oklahoma City, Okla.

ANS.—(*a*) Your account with Mr. D should be as follows:

——April 4——
Mr. D, Dr.
To Work..... 8.65
——10——
Mr. D. Cr.
By Mdse..... 8.65
——May 1——
Mr. D, Dr.
To Cash to Bal. 5.00

This shows each transaction clearly, and leaves Mr. D's account balanced. (*b*) Black oxide of copper (cupric oxide CuO) is prepared by acting on metallic copper with nitric acid to convert it into cupric nitrate, and heating this to dull redness in a rough vessel made of sheet copper, when it leaves the black oxide, as is seen from the following equation: $Cu(NO_3)_2 = 2NO_2 + O + CuO$.

***

(285) What is the composition of Roman gold?
H. H. L., Lowell, Mass.

ANS.—"Roman gold" is the term applied by jewelers to ordinary polish gold that has been dipped in acid and turned green. An improvement in the process has recently been made by which electricity is substituted for the acid.

***

(286) What kind of oil can you recommend to keep tools from rusting?
E. S., Egan, Ill.

ANS.—The best oil that we know of for this purpose, and which has been used by the writer with excellent success for a number of years, is that known as "Three in One" oil. It can be bought at nearly every bicycle store.

***

(287) (*a*) I have a single dry battery that is too powerful for a miniature electric lamp, but, by putting a coil of German silver wire in the circuit as resistance, I get the proper current to operate the light without burning it out. Under these conditions, is the battery working as hard or diminishing in strength as rapidly as when it has no resistance in the circuit? (*b*) Is there any single dry battery made that will hold its strength longer than from 5 to 10 hours when supplying current? I mean one, of course, that will be small and compact, and that would be used to light a 1 c. p. lamp. (*c*) Why is it that battery lamps are made for different voltages and currents? (*d*) Will a 1 c. p. battery lamp made for 2 volts operate as long as one made for 4 or 5 volts? (*e*) Is there not some form of battery that I can make cheaply that will run a 1, 2, or 3 c. p. lamp without being exhausted quickly, and without having to remove the zincs when not in use, as in a bichromate cell? (*f*) Where can I get the compressed-acid tablets for the Edison battery?
J. H. G., St. Louis, Mo.

ANS.—(*a*) The battery is not working as hard when the resistance is in circuit, because when the resistance is inserted, the current is cut down. The output of the battery is not, however, used economically under these conditions, because part of it is wasted

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in the resistance. It would be better to use a lamp of the same voltage as the battery, and then all the energy would be utilized in the lamp. (*b*) A small dry battery cannot be expected to hold its strength under a continuous discharge for any great length of time. If you wish a small battery for this kind of work, we would advise you to use some form of portable storage battery. (*c*) Lamps are made for different voltages in order to adapt them for use on different kinds of circuits, just in the same way that ordinary incandescent lamps are made for a number of different voltages. By having lamps made for different voltages, you can select one suited to the battery you wish to use it with, and thus avoid the use of resistance. (*d*) The length of time that a lamp will last depends very largely on the voltage with which it is supplied. If the voltage is allowed to run above the proper amount, the lamp will not last long. With a 2-volt lamp, a slight increase in voltage would probably do more harm than with a 5-volt lamp, but as far as the construction of the lamps themselves is concerned, the 2-volt lamp would have the shorter and more substantial filament. (*e*) We think you would find a small storage battery the most satisfactory for this work. The article entitled "How to Make a Storage Battery," in this issue, gives instructions for making a storage battery. (*f*) We do not know where these tablets can be obtained unless from The Edison Manufacturing Co., 110 East 23d Street, New York City.

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(288) The Baldwin Locomotive Works have recently installed in its shop a crane that has a span of 158 ft. It will lift a 196,000-lb. locomotive 40 ft. in the air, carry it 336 ft. and set it down again in 3 minutes and 36 seconds. (*a*) What horsepower is required to do this work, and how is it calculated? (*b*) Does it require as much power to lower the weight 40 ft. as it does to raise it through the same distance?

R. N. V. B., Clyde, N. Y.

ANS.—(*a*) Cranes of the kind you mention are generally provided with a number of sets of electric motors, each of which does a definite part of the work. One set raises the load, another moves the trolleys on the bridge, and a third moves the bridge along its track. The specifications for such a crane demand that the motors shall have sufficient power to do their work at a certain speed. It sometimes occurs that all three sets of motors are in operation at once—one set is lifting the weight, while another is driving the trolleys along the bridge, and the third is moving the bridge along its track. In a case of this kind, if all the motors are working up to their full capacity, the power required to drive the crane is the sum of the powers required to drive each of the three sets of motors at their maximum rate. Your very brief statement of the conditions is insufficient for an estimate of the power required to do the work. For such an estimate it would be necessary to know the weight of the crane, the distribution of the time between the different operations of raising and lowering the load and of moving it horizontally, and the general design of the crane. The general method used in estimating the power of the motors is to begin with the net quantity of work each must perform when operating at its maximum specified rate. To this must be added such values for frictional and other losses as experience shows will be required. The estimate for the power required of the lifting motors would, for example, be made about as follows: The weight in pounds to be lifted and the rate in feet per minute are given by the specifications; their product divided by 33,000 is the net horsepower that must be furnished. If it is specified that the crane must start a load from rest and lift it to a given height in a certain time, the force required to accelerate the weight must also be taken into account. Having the net power and the details of the lifting machinery, allowances can be made that will cover the probable power required to overcome frictional resistances. For moving the trolleys and bridge, the chief factors to be taken into account are frictional resistances and the force required to start the loads —including the weights of trolleys or bridges—from rest and give them their maximum speed. (*b*) In most cranes of this kind, the lowering of the weight is controlled by means of friction brakes, and the only power required is that for operating the brakes.

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(289) We have a 10-ton refrigerating machine, working on the ammonia system. The condenser capacity is 2 tons. The coils go through a brine tank in which are 6 cylinders of a capacity of 50 gal. each. A certain liquid passes through these cylinders at a rate of about 100 gal. per hour, passing from a filter through the cylinders by gravity. It enters the first cylinder at a temperature of about 60°, and passes out at the last one at about 30°. On some warm days we are compelled to shut off the liquid for 2 or 3 hours at a time, because we cannot cool it down to the required temperature. Is there a method of calculation by means of which the setting of the expansion valve to overcome the difficulty without increasing the condenser capacity can be determined? C. J. P., Brooklyn, N. Y.

ANS.—There is no rule that we know of for setting the expansion valve so as to get the required results; the required opening of the valve can be determined only by trial. Your description of the conditions is not complete enough to enable us to make any definite recommendation regarding the best method of overcoming the difficulty. It seems probable that your condenser is too small; it is, however, possible that by paying careful attention to all parts of the apparatus, and keeping it in the best possible working condition, it can be made to work satisfactorily. Be sure that the condenser is provided with a liberal supply of water, at as low a temperature as can be obtained; keep the condenser coils clean; and keep the system free from air. If all these details are properly attended to, and the expansion valve is properly adjusted, you will secure the best results possible with your outfit.

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(290) Why is it that steam from a locomotive or stationary engine will travel a long distance in the air in the winter time before condensing, while in the summer it is visible only a short distance from the engine? A. H. M., Chesaning, Mich.

ANS.—The white cloud that is seen issuing from the exhaust pipe of a steam engine is not properly steam, but minute drops of water formed by the condensation of the steam when cooled by coming in contact with the air. On a warm, dry day these particles of water are quickly evaporated into an invisible vapor; on a damp or cold day, however, they float long distances in the air before disappearing.

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(291) (*a*) In an article published some time ago you explained the method of making a blueprint from a blueprint. Is there any method of treating a Sollo print so that a blueprint could be made from it? If there is, would you kindly explain it? (*b*) Can you explain a simple process of nickelplating articles that have become slightly rusted and need a touch of nickel here and there? (*c*) Do you know of any book from which a good knowledge of architectural rendering in pen and ink, and also shading ornamental drawing with pencil, could be obtained?

E. J. S., Brooklyn, N. Y.

ANS.—(*a*) A blueprint or any other kind of a print may be reproduced from a Sollo print by first making a negative print as described in the article you refer to. If the negative print is made on blueprint paper, it must be changed in tone as previously described,

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and then rendered transparent with wax or oil. (*b*) We do not know of any process by which the plating could be applied in spots satisfactorily. About the only way, so far as we know, would be to clean the vessel thoroughly and apply a light coating of nickel all over. (*c*) "Architectural Rendering in Pen and Ink," by D. A. Gregg, in four parts, $2.00 each part. This book can be obtained from The Technical Supply Co., Scranton, Pa.

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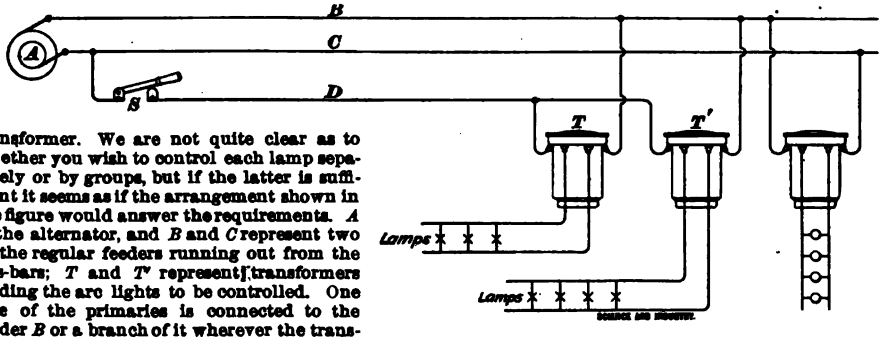
(292) Please give me your idea as to handling a number of L. B. alternating arc lamps on 115-volt secondary circuit; that is, some means of using a small third wire to handle an automatic switch at each lamp so that they may be thrown off and on without disturbing other lights on the circuit. These lamps are for street lighting. What would be a good cut-out that could be handled with a small third wire, thus doing away with the necessity of lowering each lamp to turn it off? D. B., Salt Lake, Utah.

ANS.—We do not know of any automatic switch made especially for this purpose. There is an automatic switch made by the General Incandescent Arc Light Co., of New York, that might serve your purpose, but such a switch would necessarily be used in the secondary circuit of the transformers. It is worked by two solenoids, and would require more than one extra line for its operation. If you wish to control the lamps in groups from the station it seems that the simplest way would be to run a third wire back to the station on the primary side of the



transformer. We are not quite clear as to whether you wish to control each lamp separately or by groups, but if the latter is sufficient it seems as if the arrangement shown in the figure would answer the requirements. *A* is the alternator, and *B* and *C* represent two of the regular feeders running out from the bus-bars; *T* and *T'* represent transformers feeding the arc lights to be controlled. One side of the primaries is connected to the feeder *B* or a branch of it wherever the transformers happen to be located. A third wire *D* is run back to the station and is connected through a suitable switch *S*, capable of breaking the high-tension current to the other side of the dynamo. An extra wire, such as *D*, may be run back for each transformer it is desired to control independently. Since the primary current would be small, a small wire would do for *D*. Automatic switches controlled from the station would require more or less complicated wiring, because with a switch controlled by two solenoids you would probably need three wires.

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(293) Kindly answer the following questions: (*a*) What is the boiling point of gasoline? (*b*) How many cubic feet of gas will a pound of gasoline generate? (*c*) In what proportions is this gas mixed with air for the best results, when used in a two-cycle gas engine? (*d*) Is there a formula by which the pressure developed by the explosion of a mixture of gas and air (in various proportions) can be calculated? (*e*) What is the best American book on the gas engine? P. E. K., New York, N. Y.

ANS.—(*a*) Commercial gasoline is a somewhat variable mixture of the more volatile petroleum products, the lightest of which boils at a temperature not much above 100° F. The value generally given for the boiling point of gasoline, however, is 158° F. to 175° F. (*b*) At 60° F., the vapor of commercial gasoline has a volume equal to 130 times the volume of the liquid from which it is formed, the pressure being from 6 to 8 in. of water; under these conditions, 1 lb. of gasoline will generate a little more than 8 cu. ft. of vapor. At higher temperatures the volume of the vapor will be greater. (*c*) From 6 to 10 volumes of air are generally used for 1 volume of vapor. (*d*) There is no simple formula for this purpose. If the composition of the gas is known, the theoretical pressure can be calculated by the application of well-known physical and chemical laws, but these laws cannot be reduced to a simple formula. (*e*) "Gas, Gasoline, and Oil Engines," by G. D. Hiscox, price $2.50. For sale by The Technical Supply Co., Scranton, Pa.

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(294) (*a*) I am having trouble with my Alpha De Laval cream separator. It is a No. 1 size, with 40 disks. It trembles, making a rumbling noise, and often heats in the upper bearing. It does not skim clean. (*b*) How can I calculate the amount of power needed to run a separator? (*c*) How can I polish valves and other brass fittings, and also the cylinder head of my engine? (*d*) Is there a good book on cream separators?

L. L., Sundown, Minn.

ANS.—(*a*) Some of the causes that might give the jarring and the heating of bearings are: the separator may not be properly balanced, or it may not be running at the proper speed. The failure to skim clean may be due to the speed, or to the rate at which the milk is fed to the separator. We would advise you to consult the makers, The De Laval Cream Separator Co., corner Canal and West Randolph Sts., Chicago, Ill., and get their advice regarding the changes that should be made. (*b*) We do not know of any method for making such a calculation. (*c*) Brass fittings may be polished with any good metal polish, such as electrosilicon, etc. The cylinder head may be first smoothed with a file, if it is not already smooth, and polished with fine emery cloth. (*d*) We do not know of any.

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(295) (*a*) Can a piece of machinery be moved more easily on iron rollers having a large diameter than on rollers of smaller diameter? If so, what rule is applicable, or what mechanical law applies to the case? (*b*) If we have two iron bars made of the same material, each with the same cross-sectional area but differing in lengths in the ratio of 2 to 1, each bar being supported at its extremity, what is the ratio of the weights that will be required to break the two bars, the weight being applied in the middle?

D. G. H., Niagara Falls, N. Y.

ANS.—(*a*) In general, the larger roller would enable the piece of machinery to be moved more easily than the smaller one. The principal reason is that the larger roller would not sink as deeply into the surface of the machine that it supported, and into the surface on which it rolled, as would the smaller

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roller. The larger roller would also pass over slight inequalities in the two surfaces with less difficulty than the smaller one. There is no very simple mechanical law that applies to this case. The relative ease with which the machinery can be rolled over the large and small rollers depends considerably on the smoothness and hardness of the surfaces between which the rollers are placed. (*b*) Theoretically, the shorter bar would require twice as great a load to break it as the longer one.

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(296) (*a*) Give a diagram of connections in telephones used with the common battery system. (*b*) In a telephone exchange where the charge is based on the number of connections per year, is the account of the connections kept manually or automatically?

E. H. L., Caracas, Venezuela.

ANS.—(*a*) A description of a common battery telephone system, with diagrams, is given in an article entitled "Central-Energy Telephone System," in the April, 1900, issue of SCIENCE AND INDUSTRY. (*b*) Automatic registers in the few places tried have not proved very successful; the record is made manually on tickets by the operators. However, several large common-battery exchanges have very recently commenced to use automatic registers, but they have not been in use long enough to say how successful they are. In one place where they were extensively installed a year or so ago they had to be all taken out, remodeled, and have only recently been put back again.

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(297) (*a*) Where can I learn the electrical business? (*b*) How long will it take, and how much pay ought I to expect while learning?

R. E. W., Pawtucket, R. I.

ANS.—(*a*) We advise you to get a position with an electric-lighting or electric-railway company, and in the meantime take a course of correspondence instruction in The International Correspondence Schools. (*b*) This would depend altogether on your ability and the work you are capable of doing. It would probably take you four or five years, and you should be able to get $1.00 per day to start on. If you had any previous experience you might get more than this, but, as a rule, electric-light and power companies will not pay more to a green hand.

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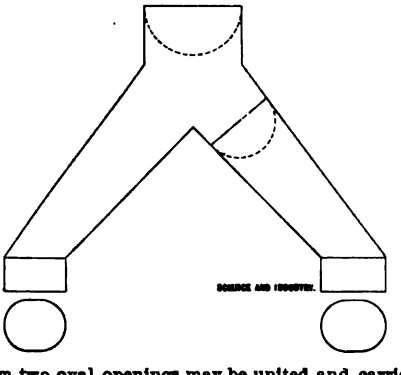
(298) Please explain the development of a branch Y, or connection piece, by means of which a blast



from two oval openings may be united and carried away by a single round pipe, as indicated by the sketch.

F. W. R., New London, Ohio.

ANS.—This development is a somewhat difficult one, and is accomplished by the method of triangulation. Drawings and descriptive matter for this problem would require more space than we have at our disposal. A thorough knowledge of the principles of projection is indispensable to one that would undertake the development of such patterns; these principles could be satisfactorily explained only in an article of considerable length.

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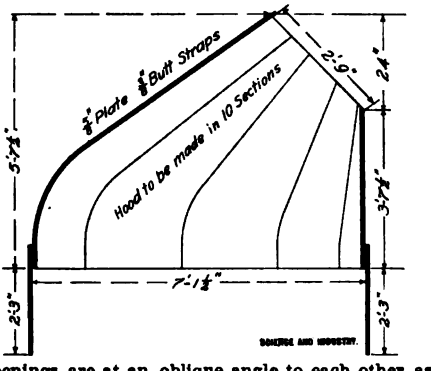
(299) Can you explain the proper method to use in laying out a pattern for a connection hood whose



openings are at an oblique angle to each other, as shown by the accompanying sketch?

J. H. B., Great Falls, Mont.

ANS.—Such drawings as you request would require more space than we are at liberty to use in these columns.

***

(300) It is desired to maintain a vacuum of 20 to 25 in. in a system of piping containing about 2 or 3 cu. ft. The leakage to be taken care of is about 2 cu. ft. per hour. There is an available water pressure of 25 or 30 lb. per sq. in. Is it possible to arrange an appliance, similar to an ejector, that will do this work?

A. J. F., Chicago, Ill.

ANS.—We think an exhauster, working on the principle of the ejector or the injector condenser, can be successfully used for your purpose. You can get full information regarding the subject by applying to the makers of apparatus of this kind. One of the following concerns can probably supply you with a device suited to your work: The Eynon-Evans Mfg. Co., Philadelphia, Pa.; Schutte & Co., Philadelphia, Pa.

***

(301) I have a copper boiler with iron front, the water supply coming from a copper tank lined with tin, through brass and lead pipes. In two or three days after the tank and iron front have been cleaned out, the water comes out red. Then, if I disconnect the front and scrape it out well, the hot water runs clear for a few days. What is the cause, and is there any cure except getting a new front? Neighboring houses have the same water, but it does not show so red. Is there a difference in the cast iron that would cause this?

W. A. H., Somerville, Mass.

ANS.—It is a difficult matter to determine precisely the cause of the rapid discoloration of the water, unless it is that the service pipe is made of black iron and is exceedingly long. There is not enough surface exposed to the action of the water in a waterback when in constant service to cause a discoloration of the water. We believe the discoloration is due to the formation of rust, but precisely where the rust is formed we cannot say. Perhaps your building is the only one that is supplied from what we may term a *dead end* of the street main, and the water may carry a considerable amount of rust with it as it enters your premises. This rust may settle in the bottom of the boiler and accumulate, and then be agitated by water boiling in the boiler. Possibly you will find that your service pipe is the only one that is taken from a dead end of the street main.

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(302) Please explain the method of calculating the safe working pressure in a Haselton "Porcupine" or a "Climax" boiler having a shell with the dimensions shown in the sketch (Fig. 1). The shell plate is steel, ⅞ in. thick, with a tensile strength of 60,000 lb. per sq. in. J. H. L., Sioux City, Iowa.

ANS.—The sketch does not show the diameter of the holes in the shell; we have assumed, however, that 4" tubes are to be used, which will give the relative distances between the holes of two adjacent rows that are shown in Fig. 2. Consider, now, the ring of the shell 8¾ in. wide, included between any two transverse rows of holes. For each pound per square inch of pressure, any longitudinal section of this ring will be subjected to a stress of $\frac{30 \times 8\frac{3}{4}}{2} =$ 57.65625 lb. The net section of the ring on the axis ab of a longitudinal row of holes is $\frac{7}{8} \times (8\frac{3}{4} - 2) = 1.15+$ sq. in. The unit stress on this section for a pressure of 1 lb. per sq. in. is, therefore, 57.656 + 1.15 = 50 lb. per sq. in., nearly. The section on the line ac through two adjacent holes in a diagonal row is subjected to the stress of 57.656 lb., which acts in the direction of the line ef, perpendicular to ab. This stress may be resolved into two components, one of which, eg, acts perpendicular to ac and tends to pull the plate apart through that section, while the other, eh, acts along the line ac and tends to shear the plate through the same section. Of these two components, eg is equal to the stress on a longitudinal section of the ring multiplied by the cosine of the angle bac, and eh is equal to the stress on the longitudinal section multiplied by the sine of the angle bac. The sine of bac is 3.5 + 5.2 = .673, and the cosine 3½ + 5.2 = .739, which correspond to an angle of 47° 40′, nearly. The tensile stress on the section ac resulting from the stress of 57.656 lb. acting perpendicular to the section ab is, therefore, 57.656 × .739 = 42.61 lb., nearly, and the shearing stress is 57.656 × .673 = 38.8 lb. In addition to the stresses due to the force that tends to break the ring through a longitudinal section, the section on ac is subjected to a stress from the action of the force that tends to rupture the shell along a transverse section. For a pressure of 1 lb. per sq. in., this force is equal to the area of the head multiplied by 1; that is, to 30² × .7854 × 1 = 706.86 lb. The number of sections among which this force is divided is equal to the circumference of a 30″ circle divided by 3.5; that is, to $\frac{30 \times 3.1416}{3.5} = 27$. The force on each section is, therefore, 706.86 ÷ 27 = 26.18 lb. This force acts on the section ac in the direction of the line el, parallel to the line ab. It may be resolved into two components, one, em, perpendicular to ac, which is equal to 26.18 multiplied by the sine of the angle bac; the other, en, in the direction of ac, equal to 26.18 multiplied by the cosine of bac. Of these two components, the first acts in the same direction as the component eg; its value, 26.18 × .673 = 17.62 lb., nearly, is, therefore, to be added to the value represented by eg, thus giving us a total tensile stress in the section ac of 42.61 + 17.62 = 60.23 lb. The component en, whose value is 26.18 × .739 = 19.347 lb., acts in the opposite direction to eh; they therefore partly neutralize each other, and the resulting shearing stress, 38.8 − 19.347 = 18.453, is so much less than the tensile stress of 60.23 lb. that it is evident the section would fail by tension and not by shear. The area of the net section of the plate, which resists the tensile stress of 60.23 lb., is 1.2 × ⅞ = .75 sq. in.; the unit stress in this section for a pressure of 1 lb. per sq. in. is, therefore, 60.23 ÷ .75 = 80.3 lb. per sq. in. Since the stress on the section ab was but 50 lb. per sq. in., it is evident that the plate will fail along the section ac. If we assume the safe working stress of the 60,000-lb. steel plate to be 10,000 lb. per sq. in., the safe working pressure will be 10,000 ÷ 80.3 = 124.5 lb. per sq. in.

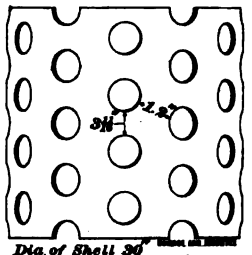

FIG. 1

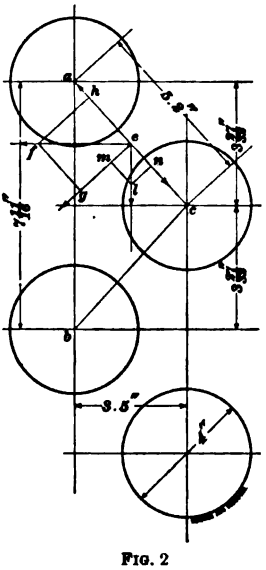

FIG. 2

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(303) (*a*) Can a storage battery be charged from a 110-volt alternating-current dynamo so as to run a direct-current motor efficiently for automobile work? (*b*) Is there any way of telling (without a compass) whether or not one field coil of a four-pole motor is connected in wrong? Will it heat up? (*c*) How can you always tell which is the positive side of a generator? (*d*) Do you know of any way to cool down a hot motor bearing? H. A. S., Chicago, Ill.

ANS.—(*a*) No; it is necessary to have direct current to charge a storage battery, and the only means by which you could utilize alternating current would be to change it to direct current, either by means of a rotary transformer or a motor generator set. (*b*) All you wish to know usually, in a case of this kind, is whether the poles are alternately of opposite polarity, without reference to whether they are north or south. Take a large sewing needle and magnetize it by bringing it into contact with one of the poles of the machine, then suspend it in the middle by a thread, and hold it opposite one pole of the machine, about a foot or more to one side. The needle will swing toward the pole. Now pass on to the next pole and the needle should swing around so as to present its opposite end, and so on all the way around, the needle pointing the opposite way as it is changed from one pole to the next. If it does not do so, it shows that the connections of the coil should be reversed. Care should be taken not to get the needle too near the poles, or else the magnetism may become reversed and render the test valueless. The coil that is connected up the wrong way would not heat any more than the others. If, however, one coil of a shunt-wound machine becomes short-circuited, it will cause the good coils to heat up, while the faulty coil will run cool. This is because the cutting out of one coil lowers the field resistance and increases the current, whereas a reversed connection makes no difference in the field resistance. (*c*) Connect one terminal of a lamp to one pole of the generator and the other terminal to a piece of wire. Connect another piece of wire to the other pole. Dip the two ends in a tumbler of water mixed with a small amount of sulphuric acid, and keep the ends an inch

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or two apart. Bubbles of gas will be given off from both ends, but they will be given off faster at the negative terminal than at the positive, i. e., the wire connected to the positive side gives off the least amount of gas. The lamp is used merely as a resistance to limit the current. (*d*) See, first of all, that the belt is not too tight; this is a very frequent cause of hot bearings on motors. Next, examine the machine and see whether the bearings have worn so as to allow the armature to get out of center in the fields. If this is the case, there may be a heavy magnetic pull on the armature that will cause heating. The remedy for this is to rebabbitt the boxes, or put in new ones. Examine the oil in the oil wells and see whether it is clean and free from grit. If there is any sign of grit in it, clean out the box thoroughly with benzine, and fill up with fresh oil. If the shaft has been cutting and if there are any ridges on it, they should be carefully removed and the shaft polished with fine crocus cloth. Any roughness of the babbitt lining should also be removed by scraping. Sometimes heating of motor bearings is caused by a heavy end pull on the armature, due to its not being centered in the field properly; the armature should play freely endwise when running. In some cases the self-oiling rings become stuck and the bearing is not fed properly with oil. In cases where it is absolutely necessary to keep running, the bearing may be cooled off by holding a piece of ice against the outer casing. Be very careful, however, when this is done, to see that no water gets on the commutator or into the armature.

***

(304) I have installed a 150 K. W. 220-volt generator, belted to a Corliss engine, and have been very careful in installing the wire to avoid grounds or leaks of any kind. In connection with the system there is 700 ft. of underground lead-covered cable. The whole system appears to be charged with static electricity, which I suppose comes from the moving belts. I feel confident that the lines are all clear. I would like to ask: (*a*) Does the machine, or the lead-covered wire, or the whole of the wire, act as a condenser? (*b*) Would such charges have a tendency to cause leaks to the frame of the machine, or through the rubber to the lead casing of the underground cable? (*c*) Does such a static charge destroy the filament in an incandescent lamp, and does it affect arc lamps? (*d*) Could I connect a condenser in the circuit in any way so as to continually discharge the lines without making a ground; if not, what form of conductor would you suggest in order to avoid the trouble? (*e*) Would such discharges on to a battery wire affect an open-circuit battery?

J. C., Chicago Heights, Ill.

ANS.—(*a*) The machine would not act as a condenser, but the whole system of wiring might act as a condenser, or rather as one side of a condenser, the ground corresponding to the other side, or in the case of the cable the sheath would correspond to the other side. (*b*) Such charges may in some cases tend to cause leaks, more, perhaps, in connection with the dynamo itself than with the wiring. Place a row of points under the belt near the dynamo pulley and conduct the charges to the ground; also, if the dynamo is at present insulated, connect the frame to the ground through a high resistance made up of three or four lamps in series. (*c*) A static charge on a belt will affect the filament of an incandescent lamp and keep it continually in vibration; for this reason it is frequently found that the filaments of lamps hanging near running belts soon break. We hardly see how a lamp with steady static charge, i. e., a lamp simply charged and not hanging near a moving belt, would be affected injuriously. (*d*) A condenser would not help matters, as it would soon become fully charged; you might try providing a high-resistance path to the ground by using a light charred groove on a piece of board. (*e*) Such discharges should not affect a battery, as the current is so extremely small that it would be incapable of producing any perceptible chemical effect.

***

(305) I am running a 25 K. W. Edison, 125-volt direct-current generator. (*a*) What would be the result if the wires running to the rheostat should in some way become disconnected or broken? (*b*) Is there any voltage between these wires at present? (*c*) Would there be if they should become broken? (*d*) How would it affect the voltage of the machine?

J. W. H., Livonia Station, N. Y.

ANS.—(*a*) If the wires running to the field rheostat were broken the shunt-field circuit of the dynamo would be opened and no current would flow around the field coils. The result would be that, if the machine were in operation, it would cease to generate, or if you were trying to start it, it would refuse to "pick up." (*b*) There is a voltage, or pressure, between these wires so long as the machine is operating. The amount of the voltage depends on the amount of field rheostat in use, and probably never exceeds 10 or 15 volts. (*c*) There would be practically no pressure between the wires if they were broken, because the dynamo would cease to generate; there might be a very small pressure due to the residual magnetism of the field, but this would be so small as to be scarcely noticed. (*d*) The voltage of the machine would drop to zero, or very nearly so.

***

(306) Will you kindly tell me how to prepare gelatine for plaster casting, and also how it is prevented from molding and shrinking when not in use?

M. A. F., New Westminster, B. C.

ANS.—Place gelatine in a small amount of water for 5 or 6 hours, and melt slowly in a double boiler. This would be more elastic if molasses in the proportion of 4 ounces of molasses to 16 ounces of gelatine is added. It should be heated just enough to thoroughly melt the entire mixture. Stir frequently while cooling, or put it in shallow pans so that it will cool evenly. The cast from which the elastic mold is made must be oiled, shellacked, or painted, and the surface must be carefully greased with hot lard or lard oil; warm the cast slightly to distribute the grease evenly. To insure a more perfect distribution, rub it on the surface with the finger. The gelatine should not be warm enough to melt the grease that has been applied to the cast, or the mold will not stick to it. A little carbolic acid will prevent the molds from becoming moldy in warm weather. Elastic molds can be kept for a considerable time if placed in a cool room and not exposed to the air. When not in use, the elastic mold should be kept covered with oilcloth or rubber cloth, so as to keep the air away from them as much as possible, which will prevent them from warping and cracking.

***

(307) I have had considerable experience in setting fireplace tiles, but I have found in some cases that they become loose, apparently by the excessive heat, especially those at the top of the fireplace. I have used the best quality of Portland cement and mortar, in the proportion of about half and half. Can you explain to me why the tiles become loose, as this is a matter of prime importance to me?

R. S., Philadelphia, Pa.

ANS.—We think this is caused by the brickwork not being thoroughly dried out before the tiles are set. Where it is not thoroughly dried out it has to "sweat" through the face of the wall, and this causes a certain amount of moisture to accumulate on the surface. An excessive heat will not only generate steam, which would throw off the tiles, but, from the fact that the face of the tile is much hotter than the body of the wall behind it, there is a movement caused by the difference in the temperature of the face of the tiles and the back sufficient to cause

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the tiles to lose their adhesion. We have experienced the same difficulty where a corner has been finished in Keene's cement, and a steam pipe being located near the corner has, by throwing off considerable heat, caused the cement to curl away from the wall. We had the cement cut out and replaced, but the same thing occurred again, which satisfied us that the excessive temperature of the face of the wall, and the comparative coolness of the body of it, caused the trouble. Another case where the tiles are apt to move is where a tie strap has not been inserted over the fireplace opening to tie the piers together. Where there is a shrinkage of the mortar or a settlement in the brickwork sufficient to cause a movement of the arch, you will readily perceive that the adhesion of the tiles would be destroyed. A great deal of trouble arises from rushing either the brick or stone masonry too rapidly, especially if lime mortar has been used, and, unless you are thoroughly satisfied that the brickwork has had sufficient time to dry out, we would advise that the tiles be mounted on a separate slab and entirely independent of the body of the wall. All new fireplaces should be heated gently, by a light fire, so as to give the work time to heat slowly. Where the heat is applied too rapidly, trouble will always ensue from cracked flue linings and brickwork, or from tiles working loose.

***

(308) Will you explain how the section of a steel strut is increased in order to sustain, besides the direct compressive stress, a bending stress? If possible, give me a formula by which the additional area required in the section to resist the transverse stress may be obtained, and also how the formula is deduced. I would like you to work out an example, with the formula, to demonstrate its application.

L. E. F., Waterbury, Mass.

ANS.—A formula by which the additional area required in a column or strut to resist bending as well as direct compressive stress may be deduced as follows:

$$M = M_1, \quad (1)$$

in which M = bending moment on the strut in in.-lb. and M_1 = resisting moment of section.

$$M_1 = QS, \quad (2)$$

where Q = section modulus of the section, and S = safe unit fiber stress of the material.

$$Q = \frac{I}{C} \quad (3)$$

in which I = moment of inertia of section, and C = distance from the neutral axis of section to the extreme fiber. From formulas (1), (2), and (3),

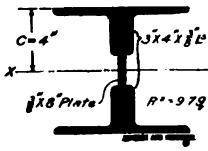
$$M = \frac{IS}{C}. \quad (4)$$

It is also known that

$$R^2 = \frac{I}{A}, \quad (5)$$

where R^2 = square of the radius of gyration, and A = area of the section required to resist the transverse stress on the column.

By combining (4) and (5), substituting and transposing, $A = \frac{CM}{R^2 S}$. In providing the additional area, or A, required to resist the transverse stress, the metal should be as evenly distributed through the section as is possible, as the radius of gyration must not be materially changed from that of the original section. If in adding the required area the radius of gyration of the section is considerably changed, the calculation must be made anew with an assumed section and an altered radius of gyration. This trouble is seldom necessary, as sufficient metal can usually be added to the section without materially changing the radius of gyration. Assume that the accompanying figure is the section of a steel-rafter member in a large roof truss, which, besides sustaining the direct compressive stress, is loaded along its entire length with a uniformly distributed load of 6,000 lb. The distance between the panel points of the truss is 10 ft., and the safe or allowable unit fiber stress of the material composing it is 15,000 lb. How should the section be increased in order to provide for the bending stress created by the uniformly distributed load? *Solution:* $M = \frac{WL}{8} = \frac{6{,}000 \times 10}{8}$ = 7,500 ft.-lb., or 90,000 in.-lb. Then, $A = \frac{CM}{R^2 S}$ = $\frac{4 \times 90{,}000}{9.79 \times 15{,}000}$ = 2.45 sq. in. Since the total area of the original section is 13.12 sq. in., the area required in the section to resist both the direct and transverse stress equals 13.12 + 2.45, or 15.57 sq. in., and to realize this area the thickness of the rolled sections will have to be increased to $\frac{1}{2}$ in. Such an increase would not materially change the radius of gyration, and the section may be designed on this basis. The thickness $\frac{1}{2}$ in. would be an unusual size for the plates and angles; they would more than likely have to be rolled specially, or the next largest stock sizes used.



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(309) Is there any practical way of estimating buildings, such as sheds, barns, small houses, etc., by the square foot? F. E. G., Bar Harbor, Me.

ANS.—There is a way of estimating the approximate cost of such buildings. Not, however, by the square foot, but by the cubic foot. The usual practice is given in the following table:

COST OF BUILDINGS PER CUBIC FOOT.

Class of Building.	Cost. Cents per Cu. Ft.
Small frame buildings, costing from $800 to $1,500	8 to 9
Frame houses, 8 to 12 rooms, costing from $1,500 to $10,000	9 to 11
Brick houses, 8 to 10 rooms	10 to 14
Highly finished city dwellings (brick or stone)	17 to 20
Schoolhouses (brick)	9 to 11
Churches (stone)	20 to 25
Office buildings (well finished)	30 to 40
Hospitals, libraries, and hotels	32 to 44

The use of this table gives only approximate results, and can only be safely used to check close estimates.

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(310) (*a*) Why is the outer rail of a railroad curve elevated; is it to overcome the centrifugal force? (*b*) Do you know of any railroads that are doing away with this elevation of the outer rail? (*c*) Can the side rod of a locomotive be keyed up too short? (*d*) I think they can be put up too short and keyed up too long. Am I right or wrong? (*e*) Are all locomotive-boiler crown sheets put up with crown bars? R. F., New Orleans, La.

ANS.—(*a*) Yes. (*b*) No. (*c*) Yes. (*d*) They can be put up either short or long, and they can be keyed up either short or long, if cranks are not set on the centers while keying up. (*e*) No; the majority have radial stays.

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SCIENCE AND INDUSTRY

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DETERMINATION OF THE MERIDIAN BY DIRECT SOLAR OBSERVATION

Benj. F. La Rue

THE METHOD OF DETERMINING THE TRUE MERIDIAN BY OBSERVING THE SUN DIRECTLY WITH AN ORDINARY SURVEYING TRANSIT

THE instructions issued by the Commissioner of the General Land Office now require that the bearings of all lines in government surveys and surveys for patent shall be determined by their deflection from the true meridian, bearings determined by means of the magnetic needle not being considered sufficiently reliable. That this is a wise requirement is evidenced by the greater uniformity and more satisfactory results obtained in the surveys. A direct outcome of the requirement, however, is the necessity for a correct and easily applied method for determining the true meridian.

For this purpose, stellar observations have been employed quite extensively, these being usually observations of the circumpolar star Polaris, commonly known as "the north star." But stellar observations have the disadvantage of being inconvenient, because they must be made in the night time, when the star observed is visible and in the proper position, which is often at a very inconvenient hour. As a more convenient means of determining the true meridian, solar observations have grown much in favor and are now employed extensively. Two general methods of solar observation for this purpose are in use, differing in the means employed rather than in principle.

One method is chiefly mechanical, by means of the solar instrument. The original solar instrument was invented in 1835, by William A. Burt, of Michigan, one of the pioneer United States deputy surveyors then engaged in the government surveys of the public lands. This instrument, as invented, is a compass having a device for solar observations which is virtually a mechanical solution of the astronomical triangle, giving the meridian mechanically from a coordinate determination of the sun's position. It is still used considerably, and by many engineers is thought to afford the best and most simple means of determining the true meridian expeditiously, although several other forms of solar attachments are now manufactured. By means of the solar instrument, the surveyor places the line of sight of his instrument in the plane of the meridian and then determines the bearing of the survey line by its deflection from the meridian. The solar instrument, while affording a convenient and expeditious means of determining the meridian, has the disadvantage of being rather cumbersome and expensive, adding considerable to both the weight and cost of a transit, while its adjustments may easily become so disturbed as to cause it to give erroneous results.

The other method is by direct observation of the sun by means of an ordinary transit instrument, having both horizontal and vertical graduated circles. It consists in ascertaining the position of the sun with reference to any line of the survey, by measuring the horizontal angle between the vertical plane through the sun and instrument and the vertical plane containing the line of survey, and in ascertaining the sun's position with reference to the horizon by measuring the vertical angle. The latter angle gives the third side of the astronomical triangle whose three angles are fixed by the pole, the zenith, and the sun; and, by solving this for the angle at the zenith, the bearing of the sun at the instant of observation is determined with respect to the true

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meridian. As the bearing of the sun with reference to the survey line has been measured by the observed horizontal angle, the bearing of the survey line can be at once referred to the true meridian.

In this method, the principle of the direct observation is substantially the same as when the solar instrument is used, but the

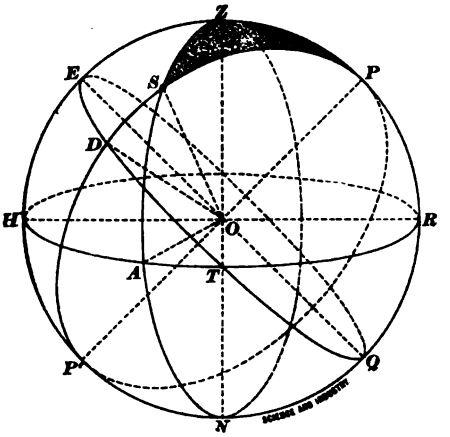

FIG. 1

bearing of the sun with respect to the true meridian, which is given mechanically by the solar instrument, must in this method be computed by solving the astronomical triangle for the zenith angle. This is the one disadvantage of the method; it is not an objection of much importance, however, as the computations, when properly performed, are neither complicated nor tedious. Moreover, as a knowledge of the direction of the true meridian is not usually required during the progress of the earlier portion of the field work, and in many cases is not required during any portion of it, the computations can usually be performed in the office under favorable conditions. This method of determining the true meridian, and the necessary computations relating to it, will now be described. Before beginning the description, however, it will be well to define some of the terms employed in spherical trigonometry, as applied to astronomical computations.

The *celestial sphere* is the imaginary spherical envelope or surface in which all the celestial bodies appear to be situated. Its radius is considered as infinitely great. In the computations for determining the true meridian by direct observation of the sun, the spherical triangle considered is assumed to lie in the surface of the celestial sphere.

The *sensible horizon* is the circle in which a plane, tangent to the surface of the earth at the point of observation, cuts the surface of the celestial sphere.

The *real horizon* is the great circle in which a plane through the center of the earth, parallel to the plane of the sensible horizon, cuts the surface of the celestial sphere. This is also called the *rational horizon*. In observations of the sun for the purpose of determining the meridian, however, no distinction need be made between the sensible and the real horizon, other than a slight allowance for parallax.

The *zenith* of the observer is the point in the surface of the celestial sphere directly over his head. It is one pole of the horizon, the opposite pole being called the *nadir*. Let Fig. 1 represent the celestial sphere and let O be the place of the observer, that is, a point on the earth's surface; the earth is, of course, very small as compared with the celestial sphere. Also, let Z be the zenith of the observer; then, $H\,T\,R$ will be his horizon.

The *axis* of the earth is the imaginary line about which the earth rotates. The same line prolonged is the axis of the celestial sphere.

The *celestial equator* is the great circle in which the plane of the earth's equator cuts the surface of the celestial sphere.

The *poles* of the celestial equator are the points where the axis pierces the surface of the celestial sphere. Let $P\,O\,P'$, Fig. 1, be the axis of the celestial sphere. Then, $E\,T\,Q$ is the celestial equator, and P and P' are its poles.

The *declination* of a star or other celestial body is its angular distance north or south of the celestial equator, the term corresponding to terrestrial latitude. Declination north of the equator is commonly distinguished by the positive sign and declination south of the equator by the negative sign.

The *polar distance*, or *codeclination*, of a star is its angular distance from the pole, that is, the complement of its declination. If S, Fig. 1, is a star, then $D\,S$ is its declination and $P\,S$ is its polar distance, or codeclination.

The *altitude* of a star is its angular elevation above the horizon, as $A\,S$, Fig. 1.

The *zenith distance*, or *coaltitude*, of a star is its angular distance from the zenith, or the complement of its altitude, as $Z\,S$, Fig. 1.

Hour circles, or *circles of declination*, are great circles of the celestial sphere passing through the poles of the celestial equator, as $P\,D\,P'$, Fig. 1.

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Vertical circles are great circles of the celestial sphere passing through the zenith of the observer, as ZAN, Fig. 1.

The *celestial meridian* of the observer is the great circle in which the plane of the observer's terrestrial meridian cuts the surface of the celestial sphere. It is the hour circle which passes through the zenith of the observer; hence, it is the hour circle which is also a vertical circle. All circles represented in Fig. 1 are projected upon the celestial meridian $PZP'N$.

The *azimuth* of a star is the angle between the meridian of the observer and the vertical circle through the star. As PZE, Fig. 1, is the meridian and ZSA is the vertical circle through S, the spherical angle PZS at the zenith is the azimuth of S, measured from the direction of the nearer pole of the meridian; that is, measured from the north, if the observer is in the northern hemisphere. EZS is the supplement.

The zenith angle Z, giving the azimuth of S, can be computed when the angular lengths of the sides PZ, PS, and ZS of the astronomical triangle PZS are known. The sides PZ and PS, being, for a solar observation, the colatitude of the observer and the codeclination of the sun, respectively, can be easily found when the latitude of the point of observation and the declination of the sun at the instant of observation are known, by merely subtracting each from 90°, and the side ZS can be found by measuring the vertical angle AS, which is the altitude of S, and subtracting it from 90°. This operation, as relating to the determination of the meridian by observation of the sun, will now be considered.

In Fig. 2, let P and P' represent the poles and EQT the celestial equator; let O be the place of the observer, let Z be the observer's zenith, let PZQ be his meridian, and HRI his horizon; also, let S be the sun. Then, ZQ is the latitude of the observer, DS is the declination of the sun, and AS is the altitude of the sun; PZS is the astronomical triangle that must be solved for the zenith angle Z, in order to give the bearing of the sun with respect to the meridian. The three sides of this astronomical triangle are: PZ, the colatitude of the observer; PS, the codeclination of the sun; and ZS, the coaltitude of the sun. These are found as follows:

The Colatitude.—As the arc PQ from the pole to the equator is 90°, the colatitude PZ is found by subtracting from 90° the latitude QZ of the observer. If the latitude of the point of observation is not known, it can usually be determined with sufficient accuracy by scaling from a reliable map or estimating by its distance north or south of some point whose latitude is known. In thus estimating latitude, an allowance of $52\frac{1}{2}$ seconds per mile of northing or southing, or $5'\ 13''$ per township, is closely approximate at latitudes of about 40°. For short distances, it is sufficiently accurate to allow 1 second of latitude for each 100 feet northing or southing.

The Codeclination.—As the arc PD from the pole to the equator is 90°, the codeclination PS is found by subtracting the sun's declination DS from 90°. The declination of the sun is taken from the "American Ephemeris and Nautical Almanac," published by the Navy Department at Washington. From the table Solar Ephemeris for Washington is obtained: *first*, the sun's apparent declination for the date of observation, with its sign + when north and — when south, remembering that this is the sun's apparent declination when observed from Washington at noon; *second*, the sun's hourly motion in declination, with its sign; this has the same sign as the declination when the sun is receding from the equator (March 22 to June 21, and September 22 to December 21), and the opposite sign from the declination when the sun is advancing toward the equator. The

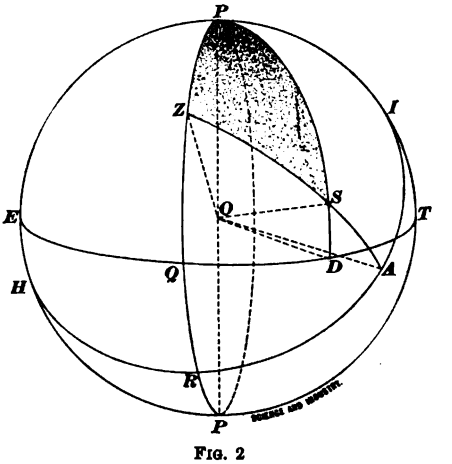

FIG. 2

difference in longitude between Washington and the place of observation is then found and reduced to units of time, calling it + if the place of observation is west of Washington and — if it is east. The difference in longitude can be taken from a map; as it is used only for the purpose of ascertaining the change in the sun's declination between noon

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at Washington and the time of observation, an error of longitude not exceeding, say, 5° will be of little consequence. To this difference in longitude, expressed in time units, must be added algebraically the number of hours before or after noon (local sun time) of the time of observation, calling it — if before noon and + if after noon. The sum will be the length of time elapsing between the time of the sun's tabulated declination (Washington noon) and the time of the observation. This should be reduced to hours and multiplied by the hourly change as taken from the Ephemeris; the result should then be added algebraically to the sun's declination for the date of observation as taken from the Ephemeris, observing the signs strictly in all operations. The final result will be the apparent declination of the sun for the time and place of observation, and the complement of this will be the codeclination, or side *PS* of the astronomical triangle.

The Coaltitude. This must be determined by direct observation of the sun. For this purpose is required a transit instrument having an arc or circle for measuring angles in a vertical plane. No special attachments are necessary, although a colored-glass shade to the eyepiece, through which the eye can observe the sun directly, a diagonal reflecting prism for observing it at high altitudes, and a ground-glass screen for receiving the images of the sun and the cross-wires, are all convenient devices, serving to facilitate the observation. The instrument should be in perfect adjustment in all respects, but especially with regard to the line of collimation and telescope level, and should, preferably, be set up over a station of the survey. It is well also to deflect to the sun from the line given by a sight on a point of reference so distant that the focus of the objective need not be changed when the telescope is directed on the sun.

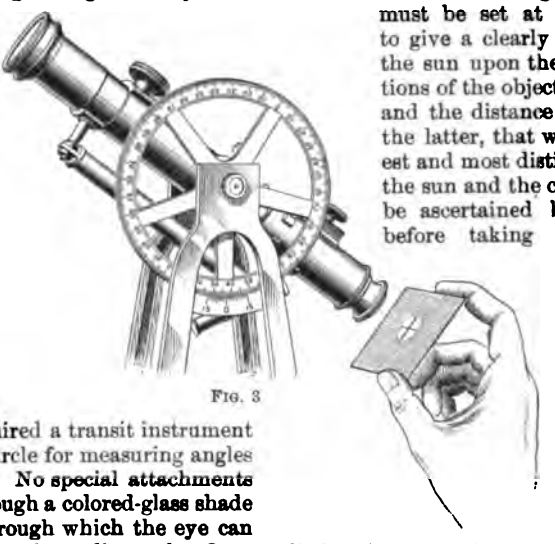

FIG. 3

The Observation for Altitude. — With the verniers of the horizontal limb set at zero, the telescope is first directed upon the distant point of reference, without regard to the vertical angle (the vertical limb should have been previously adjusted to read zero for a perfectly level sight). The horizontal limb is now unclamped, the telescope is directed toward the sun, and both the horizontal and vertical limbs clamped; then, by means of the tangent or slow-motion screws, the image of the cross-wires is made to exactly quarter the image of the sun as cast upon a piece of white cardboard held behind the eyepiece, which must be drawn out much farther than for an ordinary sight. The eyepiece must be drawn out to such position, and the card must be held at such a distance from the eyepiece, as to give a distinct image of the cross-wires within the lighted spot defining the image of the sun, somewhat as shown in Fig. 3. The objective must be set at such position as to give a clearly defined image of the sun upon the card. The positions of the objective and eyepiece, and the distance of the card from the latter, that will give the clearest and most distinct image of both the sun and the cross-wires, should be ascertained by repeated trials before taking the observation. When these have been ascertained, the objective and eyepiece slides should be marked so as to be readily set for making observations thereafter. After some practice, the surveyor will be able to obtain distinct images and to quarter the image of the sun accurately with the image of the cross-wires, getting perfectly satisfactory results by this method of observation.

Some, however, prefer to make the observation with the image of the cross-wires tangent to the edge of the sun's image, as shown in Fig. 4, one position being taken for observations in the forenoon and the other for observations in the afternoon. When the observation is taken in this manner, however, allowance must be made for the angular value of one-half the sun's apparent diameter, which varies from about 15¾ minutes to about 16¼ minutes during the year; the exact value for any given date can be found in the Ephemeris. In deflecting from the reference point, the image of the cross-wires should be brought just tangent to the edge of the sun's image, *without passing*

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across it. The angular value of one-half the sun's diameter must then be *added* to the reading of each limb in order to obtain the correct horizontal and vertical angles. It is doubtful, however, whether better, or even as good, results can be obtained by this method of observation as by making the image of the cross-wires quarter the image of the sun. Some instruments have special wires in addition to the regular cross-wires, arranged so as to facilitate the accurate quartering of the sun's image. One such arrangement is shown in Fig. 5, the manner in which it defines the position of the sun's image being shown in Fig. 6.

Whatever method is employed for making the observation, when the telescope is brought to the proper position with respect to the sun, both the horizontal and vertical angles must be read and recorded, the horizontal angle being recorded to the right or left, accordingly as it is to the right or left of the *sun*, as though the angle had been turned *from* the sun as the point of reference. The exact *local* time of the observation and the manner in which it is made, whether by bringing the image of the cross-wires to quarter the sun's image or tangent to its edge, must also be recorded. The date of observation should also be recorded, as it may be found desirable for future reference. After the observation has been made and recorded, the telescope should be again directed upon the distant point of reference, and the vernier read as a check on the angular measurement.

In this manner, a series of from six to ten successive observations should be made and recorded. This can be done rapidly; in

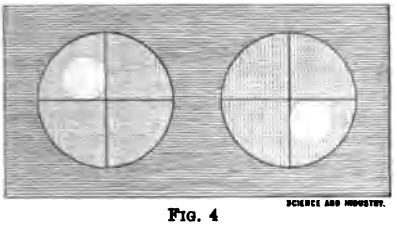

FIG. 4

fact, with the aid of an assistant to record the angles, so as to permit the observer to devote his attention entirely to the instrumental work, under favorable conditions and without interruption from clouds the series of observations can be made at the rate of about one per minute. At least two series of observations should be made, one in the morning and one in the afternoon, with the sun at about the same distance from the meridian in each case and with the telescope in reverse positions for the two series.

The observations should not be made with the sun too near the horizon, as the refraction of light is then too great; they should also not be made when the sun is too near the meridian, as the sun's change in altitude

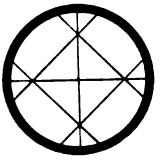

FIG. 5

FIG. 6

is then small for a considerable change in azimuth. About the middle of the forenoon and afternoon has been found to be the best times for taking the observations, giving the most accordant results in ordinary latitudes, though no set rule can be stated.

The Computations.—The vertical angles, or the sun's altitudes, as observed, must be corrected for refraction, and some allowance should also be made for the sun's parallax. The correction for the refraction is taken from a table of mean refractions; this correction must always be *subtracted* from the sun's observed altitude. The correction for parallax is opposite to that for refraction, or additive. This correction, however, is always less than 9 seconds of arc, and it will usually be sufficiently accurate to take the correction for refraction at the first even 10 seconds below its value as taken from the table, dropping the odd seconds as the correction for parallax. Having thus corrected the sun's observed altitude, its coaltitude is found by subtracting the corrected altitude from 90°.

The three sides of the astronomical triangle $P\,Z\,S$ have now been determined, being the colatitude of the observer, and the codeclination and coaltitude of the sun; it now remains merely to compute the zenith angle Z of this triangle in order to determine the bearing of the sun with respect to the true meridian, which may be done by applying any one of several well-known trigonometrical formulas.

Let $l = PZ$ = colatitude of observer;
$d = PS$ = codeclination of sun;
$a = ZS$ = coaltitude of sun;
$s = \frac{1}{2}(l + d + a)$ = one-half the sum of these three sides of the triangle;
Z = required zenith angle PZS.

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Then, from spherical trigonometry, we have directly

$$\sin \tfrac{1}{2} Z = \sqrt{\frac{\sin (s-a) \cdot \sin (s-l)}{\sin a \cdot \sin l}},$$

$$\cos \tfrac{1}{2} Z = \sqrt{\frac{\sin s \cdot \sin (s-d)}{\sin a \cdot \sin l}},$$

$$\tan \tfrac{1}{2} Z = \sqrt{\frac{\sin (s-a) \cdot \sin (s-l)}{\sin s \cdot \sin (s-d)}}.$$

The value of the zenith angle Z can be determined by means of any one of these formulas, which are easily applied, and in which the operations indicated are not laborious. It is, however, possible to derive a formula for this purpose that can be applied somewhat more expeditiously, did space permit. The value of the zenith angle Z is the sun's azimuth with respect to the true meridian at the instant of observation. The difference between this and the observed horizontal angle between the vertical circle through the sun and that through the distant point of reference will be the bearing of the line of sight on the distant point of reference.

CALIBRATION OF A GALVANOMETER

Wm. Gratz

EQUATION OF THE TANGENT GALVANOMETER—COPPER VOLTAMETER—DETERMINATION OF CURRENT STRENGTH BY MEANS OF A VOLTAMETER—DERIVATION OF RESULTS

WHEN an electric current is sent through the coils of a galvanometer, the needle of the instrument is deflected through an angle dependent on the strength of the current. The relation between the current flowing through the coil and the deflection of the needle depends on the design of the instrument. In the tangent galvanometer, the current is proportional to the tangent of the angle through which the needle is deflected.

Galvanometers are very frequently used to measure relatively small electric currents. In order that the strength of the current, in amperes, flowing through the circuit, of which the galvanometer forms a part, may be determined, it is necessary to know the galvanometer "constant." This constant is a number by which the tangent of the angle of deflection of a tangent galvanometer must be multiplied in order to obtain the amperage of the current producing the observed angular deflection of the needle. The determination of this constant constitutes what is usually termed *calibrating a galvanometer*. In other words, calibrating a galvanometer means the determination of the number by means of which the strength of the current flowing through the coils of the galvanometer can be easily calculated from the observed deflection of the galvanometer needle. The relation between the current, the angular deflection of the needle, and the galvanometer constant is, for the tangent galvanometer, to which type we will limit ourselves in this article, given by the following equation:

$$C = K \tan a^\circ, \qquad (1)$$

where C = strength of current in amperes;
a° = angle of deflection in degrees;
K = galvanometer constant.

To illustrate the method of applying the above equation in practice, we will take the following case: In order to measure the current flowing in a circuit, a tangent galvanometer was connected in the circuit. On closing the circuit, the needle of the galvanometer deflected through an angle of 20°. The constant of this galvanometer was 3.25. Applying the above equation, we have

$$C = K \tan a^\circ = 3.25 \tan 20^\circ.$$

From a table of natural tangents, we find that $\tan 20^\circ = .36397$; hence,

$$C = 3.25 \times .36397 = 1.1829 \text{ amperes.}$$

When, therefore, the numerical value of the constant K of any galvanometer is known, that instrument can be used to measure the strengths of currents that are within the limits of the measuring capacity of that instrument.

If a current, whose strength in amperes is known, is flowing through a galvanometer, the constant K of the galvanometer is easily determined by solving the above equation for K. Thus,

$$K = \frac{C}{\tan a^\circ}. \qquad (1')$$

Thus, suppose that a current of 1.1829 amperes, when flowing through the coils of a certain tangent galvanometer, causes the

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needle to deflect through an angle of 20°. Then

$$K = \frac{C}{\tan a^\circ} = \frac{1.1829}{.36397} = 3.25.$$

This method of determining the galvanometer constant would be very easy and simple, provided a standard instrument were available that would measure the current strength C accurately. Such a standard instrument, however, is an apparatus that is not available to the average person. Therefore another method for determining C, which is at the command of every person, will be described. This method depends on the determination of the current flowing in a circuit by means of a copper voltameter.

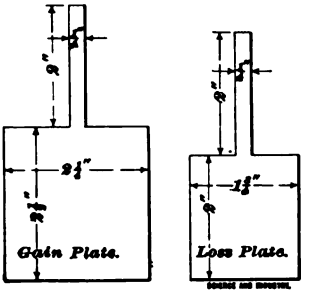

FIG. 1

A copper voltameter consists of a glass vessel filled with a solution of copper sulphate (blue vitriol) into which two copper plates are suspended from a suitable support. The apparatus can be readily constructed by means of some sheet copper and a large-sized glass tumbler. From the sheet copper are cut two plates, having the shape and dimensions shown in Fig. 1. A wooden support consisting of a horizontal bar p, which is capable of being detached from a fixed standard (Fig. 2), is next arranged. The horizontal bar carries two binding posts c, c from which the copper plates may be suspended by means of the tongues t, t and short pieces of copper wire soldered to the tongues. Fig. 2 shows the voltameter and the wooden support from which the plates are hung by means of the tongues t, t and the two binding posts c, c. By means of the screw s, the arm p may be fastened in position, and by removing s it may be lifted out of position. In the figure, the plates are shown immersed in the copper-sulphate solution. When the voltameter is connected in a circuit in which an electric current is flowing, the plates and about half an inch of the tongue should be under the surface of the liquid.

When an electric current flows through a copper voltameter, the molecules of copper sulphate are decomposed and the atoms of copper are carried along in the direction in which the current is flowing and are deposited on the plate by which the current passes out of the voltameter. That portion of the copper-sulphate molecule which remains, after the atom of copper is removed from it, passes through certain chemical changes, the final result of which is that an atom of copper is taken away from the other plate—that by which the current enters the voltameter—and a molecule of copper sulphate is again formed. The two plates of the voltameter are therefore acted on differently. The one through which the current enters the voltameter gives up a portion of its copper, while the other one receives some copper. For these reasons, the first plate is called the *loss plate*, and the second, the *gain plate*.

The weight of copper deposited on the gain plate is proportional to the amperage of the current and to the time during which the current flows through the voltameter. It has been found by experiment that a current of 1 ampere flowing for 1 second deposits .0003281 gram of copper on the gain plate of the voltameter. If, therefore, a current of C amperes flows through the voltameter for a period of t seconds, the weight in grams w of copper deposited on the gain plate will be

$$w = .0003281 \times C \times t \text{ grams.} \qquad (2)$$

If w and t are known, the strength of current can be determined by solving this equation for C. Thus,

$$C = \frac{w}{.0003281 \times t} \text{ amperes.} \qquad (2')$$

The time t can be easily determined from

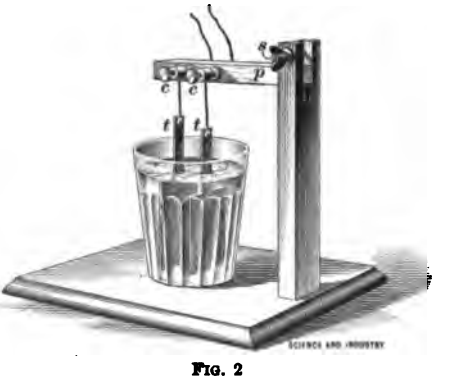
FIG. 2

observation by arranging the circuit so that it can be closed and opened quickly. With the aid of a watch, the times when the circuit is closed and opened are observed. The difference between these two observations

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gives the time during which the circuit was closed, and, consequently, the time during which the current flowed through the voltameter. The weight w can also be determined easily by weighing the gain plate before the circuit is closed, and again after it has been opened. The difference between the two weighings is the weight w that the plate has gained during the flow of the current.

To calibrate a galvanometer by means of a voltameter, a circuit is formed consisting of a source of current, the voltameter, the galvanometer, and a variable resistance, all connected in series. The best source of current for this experiment would probably be a battery of two or three Daniell gravity cells. Polarization being very slight in these cells, a current that is practically constant in value is obtained, and since the accuracy of the result depends on the constancy of the current, the above cells form an ideal source of current for this work. When, however, through some cause or other, the current strength changes, it is necessary to bring it back quickly to its former value, and, to accomplish this, a variable resistance is included in the circuit.

A convenient form of such a resistance, and one that is very simple to construct, consists of a spiral coil of stovepipe-iron wire stretched between two insulators or wooden plugs. One end of this coil is directly connected to the circuit, while the other end is free. By means of a hook formed from a stiff piece of copper wire and a sufficient length of flexible copper wire any portion of the variable resistance may be included in the circuit. The hook is hung on the coil and the flexible wire connects it with the circuit. By moving the hook along the coil, more or less resistance may be included in the circuit. To insure good contact between the hook and the coil, a small weight may be attached to the former. In Fig. 3, the variable resistance above described may be seen. The coil R is suspended between the wooden supports l, l'. The end of the coil at l is connected to the circuit, while that at l' is free. The hooks that hang from R are connected to the circuit by the wire w. Small weights p, p are fastened to the hooks to hold the latter tight against the wire of the coil, so as to make good contact.

The experiment may now be proceeded with as follows: The voltameter plates are first cleaned by rubbing their surfaces with emery paper. The gain plate, especially, should be cleaned until its surfaces are perfectly bright and free from any oxide. After having cleaned the plates, the gain plate must be weighed. In order to obtain sufficiently accurate results, the weight of the plate should be accurately determined to the ten-thousandth part of a gram. For a person that has access to the proper kind of balance, and has had experience in making such weighings, this part of the experiment will be very simple. The average individual, however, has neither access to such a balance nor the experience to use it properly. Consequently, he must determine the weight of the plate through the agency of some one else. Every drug store contains a delicate balance for weighing substances that enter into the preparation of prescriptions. Such a balance would answer the purpose of the present case, and almost any druggist, unless he should happen to be a very disagreeable individual, will readily make the required weighing.

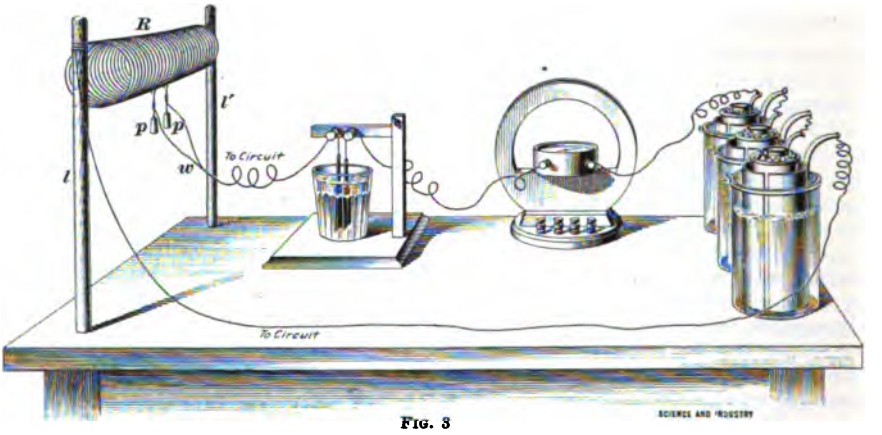

FIG. 3

After the plate has been carefully and

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thoroughly cleaned, it should be wrapped well in two or three layers of soft paper, to prevent the surface from becoming covered with oxide of copper, which it will do if it is exposed to the atmosphere. It should then be taken to the drug store, unwrapped, weighed, and wrapped up again. The circuit should next be arranged by connecting the battery, the galvanometer to be calibrated, the voltameter, and the variable resistance in series with one another, as shown in Fig. 3.

It will be noticed that the resistance R, shown in Fig. 3, carries *two* contact hooks connected to the circuit by a common wire. The object of having two hooks is to prevent the circuit from being broken and thus stopping the flow of current through it when the resistance must be varied. If only one hook were used, the circuit would be broken and the flow of current stopped when a variation in the resistance was required, because, in order to change the position of the hook, it would have to be raised from the wire, and thus metallic contact between hook and coil would be destroyed. When, however, two such hooks connected in multiple are used, as shown in Fig. 3, the position on the coil of either one may be changed without breaking the circuit, since the other hook still remains on the coil.

The galvanometer should be placed so that its coil lies in the magnetic meridian. This may be done by shifting the instrument around a vertical axis until the pointer is exactly over the zero of the scale. The voltameter is connected into the circuit by wires attached to the binding posts that carry the plates. Two auxiliary copper plates, of about the same size and shape as those described above, should be connected to the binding posts and lowered into the solution of copper sulphate. As soon as the plates are immersed in the solution, the circuit is completed and current will flow through it. The flow of the current through the circuit will produce a deflection of the galvanometer needle. The resistance should now be varied until the needle deflects through an angle of about 45°. This angle is chosen because the indications of the galvanometer are more correct for this angular deflection than for others. Having made this adjustment, the plates should be raised from the liquid and removed from the binding posts. The clean plates are then inserted and adjusted so that they are parallel to each other and their centers opposite. The distance between the two plates should be about ¼ inch. The plates are next lowered into the solution until at least ¼ inch of the tongue of each plate is below the surface, and the supporting bar is fastened. The exact time (hours, minutes, and seconds) when the plates were lowered into the copper sulphate should be observed and noted on a piece of paper.

The galvanometer needle should now be deflected through about the same angle as before. If the deflection varies very much from 45°, the resistance should be quickly varied to give a deflection of about 45°. The current should be permitted to flow through the circuit without interruption for at least 1 hour. During this time the deflection of the needle should be carefully watched, and it should be kept at a constant angle by varying the resistance and bringing it back to the original angle if it changes. After the run is completed, the plates are lifted from the solution by lifting up the arm p, and the exact time is again noted. The gain plate is removed and dried by laying it between two sheets of filter paper, which are gently pressed against the plate. The wet filter paper is discarded and the plate is again placed between two dry sheets of filter paper. This operation should be repeated several times, until the plate is perfectly dry. In handling this plate, care should be taken, from the time when its surface is first cleaned with emery paper, not to touch any portion of it with the hand except the upper part of the tongue, which is not immersed in the liquid. When the plate is perfectly dry, it must be weighed again. The difference between the two weighings gives the weight of copper deposited on the plate during the run. This weight corresponds to w of equations (2) and (2′). The difference between the two time observations gives the time during which the current flowed through the circuit. This time reduced to seconds gives t of equations (2) and (2′). By applying equation (2′), the ampere strength of the current that flowed through the circuit can now be calculated.

It will, however, be necessary to modify the above equation slightly if the druggist uses apothecaries' weights in weighing the plate, as he will undoubtedly do. The formula for finding the current will then be

$$C = \frac{31.15 \times w'}{.0003281 \times t}, \qquad (3)$$

where C = current in amperes;
t = time in seconds;
w' = weight of copper deposited in ounces (apothecaries').

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One ounce apothecaries' weight = 31.15 grams.

Having determined the current that flowed through the galvanometer, and knowing the deflection of the galvanometer needle produced by this current, the galvanometer constant K is now readily calculated by equation (1′). This practically completes the experiment; for, having determined the constant of the galvanometer, the value of any other current flowing through that particular instrument can now be calculated by equation (1).

Where the instrument has to be used quite frequently to measure currents, the work may be greatly facilitated by arranging a table giving the current strengths corresponding to angular deflections of the needle. Such a table is readily compiled by means of equation (1). Values of $\alpha°$ are assumed and the corresponding values of C calculated and arranged in tabular form. Then, when a current is sent through the galvanometer, the angular deflection of the needle is observed, and, by referring to the prepared table, the current strength corresponding to the observed angular deflection is at once obtained.

OBSERVATIONS

Weight of plate before run	.8642 gm.
Weight of plate after run	.8767 gm.
Gain during run = w'	.0125 gm.
Circuit closed (time of day)	9 hr. 25 min. 0 sec.
Circuit opened	10 hr. 25 min. 0 sec.
Duration of test	1 hr. 0 min. 0 sec.

t = 3,600 seconds.

Angular deflection of pointer = 43°

tan 43° = .93252.

CALCULATIONS

$$C = \frac{31.15\, w'}{.0003281 \times t} = \frac{31.15 \times .0125}{.0003281 \times 3{,}600} = .3297 \text{ ampere.}$$

$$K = \frac{C}{\tan \alpha°} = \frac{.3297}{.93252} = .3536.$$

In making the experiment, the precaution should be taken to remove all iron articles from the vicinity of the galvanometer. Steel or iron keys, knives, etc. should be removed from one's pockets. If this is not done, the deflections of the galvanometer needle will be affected and the results obtained will be inaccurate. Care should also be taken to properly connect the voltameter in the circuit. The connection should be made so that the current enters the voltameter through the smaller, or loss, plate and passes out from the voltameter through the larger, or gain, plate. If the connection is improperly made, the small plate will become the gain plate. This, however, is not desirable, and should be carefully guarded against. The smaller plate should therefore be connected to the positive side, and the larger plate to the negative side of the circuit.

CORRESPONDING VALUES OF C AND $\alpha°$

Deflections. $\alpha°$	Currents in Amperes. C	
30°	.2042	$\alpha° = 30°$; tan 30° = .57735; $C = K \tan 30° = .3536 \times .57735 = .2042$ ampere.
31°	.2125	$\alpha° = 31°$; tan 31° = .60086; $C = .3536 \times .60086 = .2125$ ampere.
32°	.2210	$\alpha° = 32°$; tan 32° = .62487; $C = .3536 \times .62487 = .2210$ ampere.
33°	.2296	$\alpha° = 33°$; tan 33° = .64941; $C = .3536 \times .64941 = .2296$ ampere.
34°	.2385	$\alpha° = 34°$; tan 34° = .67451; $C = .3536 \times .67451 = .2385$ ampere.
etc.	etc.	etc. etc.

The following is a report of such an experiment, giving all the data and results and indicating the numerical operations necessary in arriving at the required results. It will serve very well, both to illustrate the method of keeping observations and to indicate the numerical work required to obtain the results sought.

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STEAM PIPES AND EXPANSION JOINTS

Chas. J. Mason

THE PURPOSE OF THE MAIN STEAM PIPES—MATERIALS—COPPER AND IRON PIPING—SLIP JOINT—GOOSENECK JOINT—CORRUGATED JOINT

THE main steam pipe, as the name implies, is the pipe that conducts the steam to the main engines or pumps in a plant; it is the principal pipe through which the steam flows from the boilers to its destination. Consequently, it is the largest *live-steam* pipe in a plant.

There are different methods of erecting the main steam pipe, on account of the different conditions existing. The conditions, in turn, determine, to a large extent, by what means provision is to be made for the expansion and contraction of the steam pipe, and also govern the installation of the drainage system, which is intended to take care of the condensation. It is of the greatest importance that the two features just mentioned should receive the fullest consideration, so that proper provisions may be made to prevent an otherwise sure disaster.

The size (diameter) of the main steam pipe depends on the number and size of the units that are to be supplied with a certain quantity of steam to develop a given power. It is a question of volume and velocity. Of course, a pipe somewhat larger than the one found necessary by calculation should be installed, since allowance must be made for the distance between the source of supply and the place of delivery, which distance determines the condensation. Covering the pipe will reduce condensation, but cannot entirely prevent it, owing to the impossibility of preventing the radiation of heat; hence the necessity of a slightly larger pipe than figures call for.

The thickness of the main steam pipe (or any other) depends on the diameter and the pressure sustained. The pressure causes what is termed a *stress*, and the stress to which the material of the pipe may be subjected depends, in turn, on the tensile strength of that particular kind of material; in short, the same method of determining the safe pressure that may be carried in a boiler can be applied to the steam pipe. If the pipe has a riveted joint, then the percentage of strength of the joint, as compared with the solid plate, will have to be determined as in boiler calculations.

We do not usually calculate the strength of the smaller pipes, for they are made to withstand a much greater pressure than they will ever be called on to bear in the steam plant. When extra high pressures are used, such as in hydraulics and compressed air—when the pressures run up in the thousands of pounds per square inch—then the pipes are increased in thickness to meet the requirements. But in any case, the diameter, thickness, volume of steam to be transmitted, and the pressure carried are relatively dependent on one another.

The materials used for steam pipes are copper, wrought iron, and steel. Copper is frequently used on shipboard, not only for the main steam pipe, but for many others, such as feedpipes, discharge pipes from all the pumps, etc.; in fact, on many steamships, such a thing as an iron pipe is seldom seen.

Of course the main steam pipe on a ship is much shorter than that of a modern steam

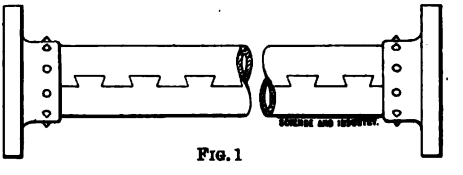

FIG. 1

plant on land. To install a copper pipe in the latter place would necessitate the expenditure of a large sum of money, hence iron pipes are used instead. But it may not be amiss to briefly mention something about copper pipes.

For small copper pipes, the seams are simply brazed, similar, in comparison, to the weld of an iron pipe. Copper pipes of large diameter are usually riveted at the seam, or are dovetailed and brazed, as shown in Fig. 1. This last-named joint is very strong, and makes a very neat job. The method of making a pipe of large diameter, so as to conform to the ultimate shape or bend of the pipe when in position, is as follows: The boiler and engine being set in their permanent positions, respectively, a templet made of wood—a mere framework—is fitted between the flanges to which the actual pipe when finished will be connected. The

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idea of this is to get the correct distance between the flanges, to produce the proper bend, as indicated by the outline of the templet, and to have each flange lay in its proper plane, thereby insuring against

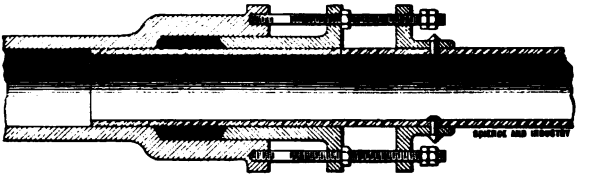

FIG. 2

the necessity of having to spring the pipe into place, so that the bolts may be entered in their several holes in the flanges. After the templet has been fitted correctly, it is taken to the coppersmith's shop and set upon the floor as a guide by which to make the pipe.

It will be understood from the foregoing that there are no "elbows" and "tees," such as are used in screwed iron pipe, needed in the construction of a line of copper pipe. When outlets or branches are required in the main pipe, they are made by riveting on and brazing a properly prepared throat-piece that conforms to the curvature of the pipe to which it is to be connected. All the bends are made of large radius.

Copper is used for piping because of its toughness and ductility, and also because it can be easily worked into shape. Not only that, but, unlike iron, it does not suffer from corrosion. When properly made, copper pipe is considered by many to be much better than iron pipe, and also safer, but then it is much more costly.

Now, in regard to the main steam pipes that are made of iron, it may be said that there are three different kinds: flanged, with riveted joints; flanged, with lap-welded joints; and lap-welded screwed pipe, with the usual fittings. The first mentioned, used for large mains, have heavy cast-iron—sometimes steel—flanges that are riveted to the pipe. The requisite branch outlets are obtained through a casting, one side of which is made to conform to the pipe to which it is riveted, and it is then calked steam-tight, and the other side is a plane-faced flange to which a valve or a similar flanged pipe may be connected.

The second kind (flanged, with lap-welded joints) is used for moderately large mains, and for pipes that connect the individual boilers to a main, as in a large plant where there are a number of boilers. When used thus, the flanges are usually riveted on, and the pipes have no side outlets; but, when this class of pipe is used as a main, as in a small plant with only one or two boilers, the flanges are usually screwed on to the pipe, the elbows, tees, and other fittings being also connected to screwed-on flanges. All the fittings of this class of piping are usually cast iron. In some of the smaller flanged iron pipes, the flanges are made of wrought iron, thereby giving strength and insuring non-liability to split when screwed on the pipe or to crack when the bolts are drawing the flanges together to make a joint.

The third kind of piping (lap-welded screwed pipe, with the ordinary fittings)

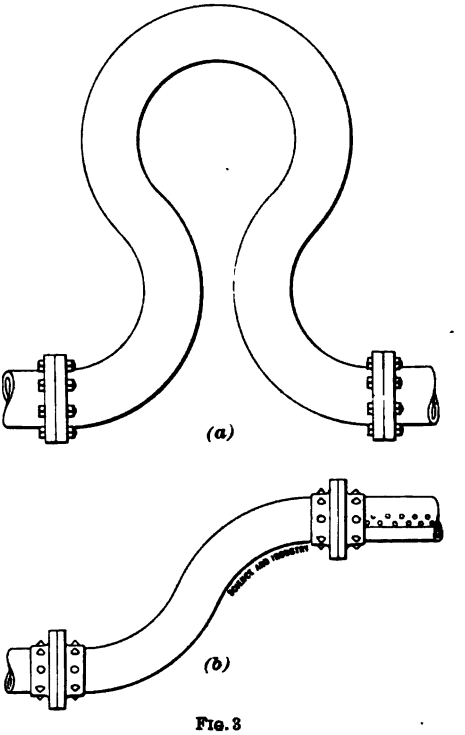

FIG. 3

is used for mains and other pipes in small plants. All the joints in this class of piping, with the exception of ground-joint unions, are screwed. Elbows are used to change the direction of run, and tees admit of a branch outlet connection.

Having briefly described the different kinds of piping used for steam mains, we

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will now consider how the expansion and contraction, to which metals are subject owing to changes in temperature, is taken care of, and what disposition is made of the water of condensation within the pipe. These are points of vital importance.

There are two general methods of providing for expansion. Fig. 2 illustrates the "slip" expansion joint, which admits of the pipe expanding—slipping in to the full extent called for by the temperature. The screwed studs passing through a fixed flange on the pipe are an additional safeguard. These nuts are not to touch the flange at any time, since this would counteract the purpose of the expansion joint; they are adjusted so as to prevent the possibility of the pipe ever coming entirely out, which, of course, would cause disaster. It was owing to such an accident that the present form of slip joint, with the extended studs through the fixed flanges, was designed.

A second method of providing for a change in the length of a pipe is illustrated in Fig. 3. At (*a*) a copper pipe, bent as shown, is bolted to the flanges of the pipe. This is usually called a *gooseneck* expansion joint. Owing to the shape, it is quite elastic and is well adapted to take care of all changes in length that are likely to occur. Attention is called to the fact that, when installed, it should invariably be placed with the gooseneck up, or as shown in the illustration. Occasionally, a bent pipe like that shown in Fig. 3 (*b*) is used.

There is a third method of providing for expansion that is sometimes used on exhaust pipes in large plants; this is simply a short section of corrugated (usually copper) pipe. Such an expansion pipe, shown in Fig. 4, is used where the space does not admit of a curved pipe being used. This class of expansion pipes really comes under the heading of curved pipes, since the action is practically the same, which is the straightening out of the bends or curves, thus permitting contraction to take place without danger to the pipe. The expansion acts in an opposite and equal manner.

It may be well to call attention to an error in connection with expansion joints into which many people unconsciously fall. They assume that the expanding of the pipe will cause the pipe to slip *out* of the joint in case of a slip joint. Very little thought will show that the pipe must slip *into* the expansion joint in order that the length over all of the piping will not be changed. In case the pipe contracts, it will slip *out* of the joint.

If no provision were made to admit of the pipe alternately expanding and contracting, then something would give way under the strain; usually the joints would start to leak all along the line. The extent of the injury sustained would depend on the extremes of temperature affecting the pipe, and also on the length of the pipe itself. The coefficient of linear expansion is given as follows:

Copper	.00000955
Iron	.00000686

These figures give the amount of expansion per foot and degree. It will be seen from this that a steam pipe need not be very long in order to wrench the weakest fittings apart, if proper provision is not made for expansion. For example, suppose we have

FIG. 4

a main steam pipe 100 feet long; the pressure carried is, say, 150 pounds gauge; before the steam is turned on from the boiler, the temperature of the pipe is 70° F. We find, on consulting the "table of properties of saturated steam," that steam of 150 pounds pressure has a temperature of 366° F.; therefore, the difference of temperature will be $366 - 70 = 296°$; continuing, we find that our pipe will increase in length under the stated conditions, $100 \times 296 \times .00000686 = .203$ feet, or 2.4 inches, which is an amount requiring provision for its care.

In actual work, the amount of expansion is rarely calculated from the temperature difference; the usual rough-and-ready rule is to allow for 3 inches of expansion for every 100 feet of pipe.

It must not be assumed by the reader that the expansion joints and kinds of steam pipes here described are the only ones in use. These have been selected simply on account of their being most universally used. For instance, cast-iron pipe is occasionally employed for main steam pipes.

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KINKS ON RANGE CIRCULATING PIPES

M. L. King

How Steam Blows From Hot-Water Faucets—The Circulation and Sediment Pipes. Wedging the Water Front

IT WOULD seem, from the large number of kitchen ranges and range boilers in use, that the methods of heating the water in such boilers should be thoroughly understood and the subject itself exhausted. It is, however, the very diversity of the methods employed and of the efficiencies obtained that prompts the writing of the present article.

What is commonly called the "boiler" is really a hot-water storage tank. The boiler proper, if there really is such a thing connected to the system, is represented by the water front in the range. It should be the intention, however, to so arrange the piping and connections that boiling of the water or steaming will not readily occur. To avoid confusion, the trade terms of "boiler" and "water front," as ordinarily understood, will be used in this article.

At atmospheric pressure, steam forms at a temperature of 212°, while at a pressure of 50 pounds per square inch, which is quite common in ranges connected with city mains, steam forms at 297°. It is thus seen that water may be heated to considerably over 212° and still occupy the entire space in a range boiler. When this condition exists, and the hot-water faucet is opened, the faucet will "spit"; that is, discharge water and steam intermittently, and rather violently, until the entering cold water mixes with and reduces the temperature of the water in the boiler below the boiling point. Steam will sometimes issue from the hot faucet in such a volume that we may imagine the boiler to be filled with steam, when it really is filled to the top with water at a high temperature.

The heating of water to such high temperatures in range boilers is undesirable, and may be avoided to a great extent by properly proportioning the sizes of boilers to the water fronts to which they are to be connected.

It is seldom advisable to use a boiler of less than 30 gallons capacity, and it will be found good practice to use that size with water fronts having an area of about 75 square inches exposed to the fire. With water fronts having an area of between 80 and 100 square inches, a 40-gallon boiler may be used. With water fronts having an area of between 100 and 120 square inches, a 50-gallon boiler is advisable, etc. Of course, such figures as are here given are mere averages, no account being taken of the *service* required in the range in which the water front is placed. Enough has been said to show that judgment must be used in selecting the proper size of boiler.

In addition to the steaming at the faucet, steam may also be formed in the water front when the water in the boiler is comparatively cool. This is caused by the use of circulating pipes that are too small or have become obstructed in some way. The water is then unable to flow through the water front fast enough to carry the heat to the body of cooler water in the boiler, and the steam bubbles thus formed produce a series of very annoying tapping sounds.

It is, of course, well understood that the circulation of the water through the pipes leading from the boiler to the water front, and back again to the boiler, is caused by the difference in density (which means a difference in weight of given measured quantities) of the water in the water front and in the pipes of the circulation system. The power to move the water and cause it to circulate is furnished by heat imparted to the water front by the burning fuel. The laws governing the circulation of water are even more irrevocable than the laws of the Medes and Persians, and the slightest infraction of them is sure to cause a rebellion.

It is essential, then, to provide water front and pipes with unobstructed waterways, and the top, or *flow*, pipe from the water front should pitch upwards all the way to the boiler. It is sometimes unavoidable that the circulation pipes should be run around behind the range, but they should be as short and direct and with as few fittings as possible.

The bottom, or *return*, pipe should be dropped near the boiler to a point an inch or two below the bottom opening in the water front, so that any sediment or rust flakes will stop at that point. For this reason, a "tee," and not an elbow, should

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be placed at the lowest point, and an elbow, nipple, and faucet of the same size as the circulating pipe does service as a sediment chamber, from which the sediment should be frequently drawn off. The general practice has been to connect the sediment pipe to the waste pipe near the sink, but it is evident that the condition of the water cannot be seen when so connected, while, from the unconnected faucet, one may readily see the color and condition of the water in the sediment chamber. Then, too, with the sediment pipe connected to the sewer or waste pipe, the boiler and water pipes may become charged with vapors from the sewer, if the sediment cock is left turned on after the boiler is emptied. It behooves the young plumber, when making repairs, to see that the washer in the sediment faucet is in good condition, and free from hard substances before refilling the boiler. He will thus escape the humiliation of being "turned down" by the cook because the faucet leaks and the boiler must be emptied again to put in a new washer.

The circulation, or range, pipes perform the hardest kind of service, and should be carefully selected and fitted. While ¾-inch pipe may be large enough for some water fronts, it is better practice to use 1-inch pipe wherever possible. A brass-pipe range job, while about four times the cost of the same job in galvanized pipes, is, nevertheless, cheaper in the end, for the iron pipes rust out quickly. Whether brass or galvanized pipes are used, the inside ends of all pipes and nipples should be reamed out larger than the diameter of the pipe, so that the friction may be reduced to a minimum. It is well to keep in mind, too, that a pipe is not larger than its smallest area; and the operation of cutting the pipes always leaves a "burr" that reduces the area to a considerable extent.

The ordinary brass boiler coupling and "spud" is durable and convenient, but should be discarded when fitting with 1-inch pipe, as the couplings are seldom more than ¾ inch in diameter, and often less. The ordinary threaded "union" should therefore be used, and, if of brass with ground face joints, there need be no fear of its ever leaking. With the galvanized union, something more substantial than the common cloth insertion rubber packing should be used, as the service required is nearly the same as is required in a steam-power plant. A little care in red-leading the screw joints will be time well spent. It is very slovenly to smear the whole length of the inside threads of the fittings with an excessive amount of red lead or joint grease. A better way is to use a small stiff brush, and apply a thin coating on the inside of the threads for only ¼ inch back from the entering end of the fitting, and an equal amount on the entering end of the outside thread. The slovenly way is a trifle the quicker, but it leaves the inside of pipes and boiler so greasy that the evidence will appear for several days on the inside of the bathtub.

When connecting a water front, put it where it belongs and wedge it tightly in place with pieces of wood extending across the firebox, so that the front end cannot spring away from its place by reason of a strain on the pipes. A space between the water front and the range side would allow a stream of air to interfere with the draft of the range and cool one side of the water front. To further guard against this trouble, a little fireclay may be used to point up the joint along the top of the water front.

A cloth fastened to an old file and saturated with gasoline or kerosene and properly applied to the job when finished will not only add greatly to its appearance, but will also add to your reputation for neat work.

When taking down a boiler that has been in use for some time, remember that there is inside of it a lot of rusty, slimy mud just aching for a chance to spill out and spread itself all over the kitchen floor.

If the young plumber will act on the foregoing hints, and use a little discretion and a great deal of old carpet to catch the surplus dirt, the householder will say to the boss: "Send the same young man that fixed up my range boiler."

In conclusion, remember that if the job takes a little longer than expected, the owner may "kick," but will soon forget about it. If, however, the job is improperly done, he will never forget it, because the evidence of poor work is constantly before him.

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GASOLINE ENGINES FOR AUTOMOBILES

E. W. Roberts, M. E.

STEAM, ELECTRICITY, AND GASOLINE AS PROPELLING AGENTS—ADVANTAGES AND DISADVANTAGES OF EACH—METHODS OF SPEED CONTROL

IN FRANCE, the country in which the automobile was first taken up in earnest on business principles, there are over five thousand of these vehicles in use at the present time, more than 75 per cent. of which are driven by gasoline engines. In England, the electric vehicle and the steam-driven automobile are about equally in favor, while the gasoline automobile is slowly but surely becoming better understood, and in time is certain to outdistance its rivals. In the United States, where the electric vehicle practically saw its birth about five years ago, at which time its manufacture was taken up seriously and on a commercial basis, electricity has far outdistanced all competitors. Steam and gasoline are vying with each other for second place, and it is difficult to tell, without having the exact figures, which one of these prime movers is the greater favorite in this country.

Each one of these various methods of propelling the horseless vehicle has advantages not possessed by the others, and each also has disadvantages that make it objectionable for various uses. Disadvantages possessed by one method may not appear in the other, and, in consequence of this state of affairs, each class of vehicles has a field to which it is particularly adapted. Electricity is, perhaps, the most noiseless of the three, the power is readily controlled, and, when the apparatus is in proper working order, the carriage responds instantly to the movement of an easily operated switch. There is no odor, no danger from fire, and no possible chance of discomfort in any way from heat. This method has, however, its limitations, and, with the exception of a few specially made vehicles, the battery has to be recharged after a run of from 25 to 30 miles, because of the impracticability of using anything else but lead for a storage cell that will meet all requirements of the service. The interest on the high price of the vehicle, as well as the fact that there is great waste of power in storing the energy and in giving it out again to the motor, and also the cost of the current as ordinarily supplied, makes the operation of the vehicle an item of considerable expense. The steam automobile has a wider range of operation than the average electric vehicle, but it requires much more fuel and a larger supply of water for the same mileage than a carriage driven by means of a gasoline engine. In fact, many of the smaller automobiles that employ gasoline engines as a motive power, require no water, because the cylinders are cooled by means of radiating ribs or flanges. A steam automobile has about it much complicated machinery and many attachments, which, in spite of the many assertions to the contrary, require a great deal of attention to keep them in proper working order. A carefully designed gasoline carriage is about as simple as could well be imagined, although the writer must admit that the general trend of the designer has, unfortunately, been toward an excessively and an unnecessarily complicated mechanism.

The field of the electric vehicle is practically confined within the limits of a city, and even to a city in which there are no heavy grades to climb. In any place like Cincinnati or San Francisco, where the grades are numerous and very steep, the electric vehicle is practically useless for the reason that when it gets to the top of a hill of any extent, the power is usually exhausted. The steam automobile has a wider range of operation, but owing to the large amount of fuel and water that must be carried per mile, it is not adapted to long journeys, especially when the points of fuel supply are widely separated. For the gasoline vehicle, which has a very wide range of operation on an ordinary supply of fuel and water, this objection does not hold. It is undoubtedly the vehicle for long journeys and pleasure tours, particularly through a district in which the supply of fuel is apt to be uncertain.

One of the first requisites of a gasoline engine for automobile purposes is simplicity. It is scarcely necessary to add that the most successful automobile engines are those that have the fewest parts. The writer has seen more automobile engines of the gasoline type relegated to the scrap heap because of complicated mechanism than for any other reason. It is strange, but true, that the

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majority of experimenters with gasoline automobiles have been anything else but gas-engine experts. They seem to have started with the assumption that, because a gas engine is a very simple device, automobiles could be built by any one, and when they got in difficulty, instead of discarding that portion of the mechanism causing the trouble, they added another part, until the engine became as complicated as a harvesting machine.

If the reader should be inclined to experiment in this line, the writer would advise him to use every effort toward the reduction of the number of parts to a minimum. Do not hesitate to sacrifice economy of fuel to effect a gain in simplicity. Do not attempt high compressions. In a four-cycle engine, one cam-shaft should be made to operate all valves, igniters, pumps, etc. that may be employed, no matter how many cylinders are on the engine. The engine can be greatly simplified by using an inlet valve operated by the suction of the piston, and if a jump spark is employed, but one cam is necessary. A good principle to keep in mind when designing a gas engine is to entirely avoid the use of a flat spring for any purpose. Helical springs, commonly, but erroneously, called spiral springs, should be employed wherever a spring is required. In connecting up the wires for an electric igniter, soldered joints are much to be preferred to clamps, for the reason that the best of clamps or binding posts will work loose, owing to the constant jar of the vehicle. For the same reason, it is advisable to use large wire, say No. 14, as smaller wires are too liable to break. All wire should be covered with the very best of weather-proof insulation, and it should be carefully supported so that it will be free from hanging loops and sharp bends.

The jump-spark method is finding great favor among the builders of gasoline automobiles, because it gives much better satisfaction at the high speeds at which engines for this purpose are operated. The reason for this is that very little dependence can be placed on springs, because there is always a time element present. In other words, it requires a definite amount of time for the spring to expand or contract, as the case may be. High speeds are employed for the reason that the horsepower of an engine increases directly in proportion to the speed, and the weight of the flywheel requisite for the successful operation of the engine decreases directly with the third power of the speed. As the flywheel often constitutes quite a large percentage of the weight of the engine, this is a matter of no small importance.

The two-cycle engine is rapidly growing in favor with the gas-engine designer as it becomes better understood. It is possible to design an engine of this type with practically no moving parts except the piston, the connecting-rod, and the crank-shaft, and, when the engine uses the jump-spark method of ignition, no spring is necessary beyond that required to hold the brush on the commutating switch. The beginner is, however, strongly advised to leave this type of engine severely alone, unless he has had considerable experience in this design. Although it is, without doubt, the most simple of all prime movers to construct, it has to be very nicely proportioned in order that it may work successfully.

The matter of cooling the cylinders of an automobile engine is puzzling to a great many, especially as, when a water-jacket is employed, a certain quantity of water must be carried, and its use adds considerably to the weight of the carriage.

In France, this objection has been overcome to a great extent. The manner of doing this is to supply a cooling chamber, similar to a steam radiator, as a part of the circulating system for the water. The pipes of which the cooler is comprised are surrounded with a great number of flat collars or disks, which greatly increase the radiating surface. When the vehicle is in motion, a current of air is constantly passing over the exterior surface of the cooler. If the radiating surface is sufficiently large, no water is evaporated and there is, consequently, no necessity for renewing the supply at any time. The use of water that is dirty or that contains a large quantity of lime may be avoided when this device is employed. While many assertions to the contrary are made by uninformed persons, it is nevertheless true that a great deal of trouble has been caused by the deposit of lime or sediment within the water-jacket. It is therefore advisable, whenever possible, to use rain water for cooling the engine. As rain water may contain materials held in suspension that will deposit in the jacket, it is not a bad idea to use water that has been thoroughly settled by standing for several days in a barrel or other receptacle.

Handling gasoline for an automobile engine has probably been as much of a stumbling block as anything else. Improperly designed

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devices of this kind will give an irregularity of supply that is very detrimental to the operation of the engine. They will, at one moment, flood the cylinder with gasoline and at the next moment supply none at all. This causes the engine to work by fits and starts, and, besides decreasing its power, often causes it to stop in a seemingly unaccountable manner, much to the annoyance of the operator. Another frequent cause of trouble, and one that is also due to faulty design, is premature ignition, popularly termed "back firing." Premature ignition is due to various causes, but is almost invariably produced by improperly placing some part of the mechanism that projects into the compression space, or by permitting a projection on the end of the piston. Quite often it is due to the igniter points being placed where they will become very hot, and thus act in the same manner as the ignition tube, but firing the charge before the proper point in the stroke. The writer knows of cases in which the engine, after having been run a short time and the igniter turned off, would continue to run because the charge was ignited by some incandescent projection within the cylinder. If the projection itself does not become incandescent, it is quite likely that it will collect a deposit of carbon, either from the fuel itself or from the cylinder oil. This deposit takes the form of a cone or thin flake, which becomes very hot and acts in the same manner as an overheated projection. Always place the igniter point in the path of the incoming charge, and as close to the point where it enters as is possible. It is also a good idea to place the igniter so that the jacket water will come as close to it as possible, in order that it may be kept cool by this means.

An annoying feature of a gasoline engine is the vibration that it is liable to transmit to the carriage, particularly when the engine is running and the carriage is standing still. Even an engine that is very well balanced will vibrate from the shock of the explosion, and no amount of mechanical balancing will absolutely overcome the trouble. This effect may be avoided by placing the cylinder so that the axis is vertical, thus making the direction of the shock downward and in a direction in which it is better resisted by the framework of the carriage. The shock has also been overcome in a horizontal engine in the following ingenious manner: Two cylinders are employed, the axes of which are directly in line, the open ends of the cylinders pointing directly toward each other; the crankpins are set opposite, or at an angle of 180°; the pistons are then approaching and receding from each other at each alternate stroke. The cycle is so arranged that the explosions occur in each cylinder at the same time, so that the force of each explosion is in a direction opposite to that in the other cylinder, and the shock to the frame is annulled by the explosions counterbalancing each other. This arrangement has the added advantage that the mechanism of the engine is in perfect mechanical balance. The results of this design in practice are apparently all that can be desired. It is also possible to so connect the combustion chambers of each cylinder that both may be controlled by one set of valves and one igniter.

The automobile gas engine has brought into general use an entirely new method of speed control that is very simple and at the same time exceedingly effective. It is known as "varying the lead of the spark." It is quite generally known that in order to get the best effect from the gas engine, the explosive mixture must be ignited shortly before the piston reaches the end of the compression stroke. The ignition is then said to have lead, and in order to distinguish it from late ignition, it is quite often said to have *positive* lead. Late ignition is generally spoken of as ignition having *negative* lead. If an engine is so arranged that the lead of the spark may be changed from early to late, or vice versa, the speed may be controlled without altering the proportions of the charge or the amount of the mixture that enters the cylinder. The earlier the ignition, the greater will be the mean effective pressure in the cylinder, and this pressure will be decreased as the ignition is made later. If the ignition takes place about half way on the expansion stroke, the engine will have scarcely more power than will overcome the friction of the mechanism, so that the speed may be varied within wide limits by this means. While this method is one that is not, in general, conducive to economy, it has been found an exceedingly convenient one in automobile practice.

In the early days of the gasoline automobile, it was thought necessary to run the engine at a constant speed and to supply a complicated speed-changing gear. It has been pointed out by an expert in this line that a greater part of the power developed by the engine was wasted by the transmission gear. It is now customary to make a

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speed-changing gear with but two changes, one for ordinary traveling and the other for climbing steep grades, while the speed of the carriage itself is controlled by varying the speed of the engine. The variable-ignition method is quite frequently supplemented by a device for throttling the charge. The old-fashioned hit-and-miss method is very seldom used. The method of controlling the spark is very simple when used with the jump-spark method of ignition, and consists of rotating the brush of the commutating switch around the shaft.

Much trouble has been experienced with ignition apparatus, especially with the battery, because of the great amount of churning action, due to the vibration of the vehicle. Much attention has been paid to this matter by designers of apparatus for furnishing current for the igniter, and, among other ways of overcoming the difficulty, there have been devised battery cells in which the electrolyte (the liquid) is held in a pasty mass or by some porous substance. In a certain form of caustic-soda cell, the use of oil has been avoided by a tightly sealed cover. One maker of automobiles has deemed it necessary to do away entirely with the use of the primary cell and to employ a storage battery. A great many have employed small dynamos of various kinds, but, in almost every case, it has been found necessary to employ a battery for furnishing the current until the engine was started and the dynamo ran at a speed sufficiently high to give the requisite pressure. The writer recently learned of a dynamo so designed that it will give sufficient pressure at a very low speed, and stand an increase of this speed of about 400 per cent., so that the use of a battery for starting is unnecessary.

Perhaps the greatest inconvenience attached to the operation of a gasoline vehicle is the fact that the majority of them must be started by first turning the engine over with a crank until it has taken up its cycle. This objection has been overcome to a certain extent in the motor cycle by so arranging the mechanism that the engine may be driven by foot-power until the gas engine has been started. In vehicles of the carriage type, several methods of starting the engine from the carriage seat have been devised. In one, a lever is employed, operating a ratchet on the crank-shaft, and, by pumping the lever back and forth, the engine may be started while the operator is in the carriage. In one method, probably not now in use, the engine is started by means of the sparking dynamo, which becomes for the moment a motor and is driven by a small storage battery supplied for the purpose. Another method is one in which the motor is started by a small tank of compressed air, the supply of air being replenished by a pump while the engine is in operation. In a carriage, lately brought out in France, the advantages of both the electric and the gasoline carriage are combined by the employment of a storage battery and a motor in addition to the gasoline engine. The motor starts the carriage and keeps it going until the engine is under way, when current is cut off from the motor and the engine drives the carriage. The motor is then used as a dynamo to replenish the battery. In case a steep grade is encountered, the motor will assist the engine. Although this combination may appear unnecessarily complicated, it has advantages that can scarcely be obtained in any other way.

In a patent recently granted for an automobile engine, an excess of power over that which could be obtained under normal conditions is derived from the engine in the following manner: A supply of compressed air is kept in a tank provided for that purpose and employed when required for starting the engine. When an excessive power is desired, as, for instance, when climbing a heavy grade, the charge is composed of compressed air and gasoline, thus more completely filling the cylinder and at the same time increasing the pressure after compression. It is claimed that at least 25 per cent. more power may be obtained from the engine by the use of this device. Not long ago the writer saw a two-cycle engine operating with gas derived from crude oil, in which case no air was apparently admitted to the engine, and, to all outside appearances, the engine was operating with gas alone. Further investigation proved that the gas supplied to the engine contained a large percentage of air, the balance being a vapor or gas derived from the oil. In this case, the gas, or carbureted air, was supplied to the engine at a pressure of 15 pounds to the square inch, and the crank-chamber of the engine was not used for compressing the mixture. According to the inventors, the mixture contained 96 per cent. of pure air. A company has lately been formed for the purpose of operating gasoline-driven railway cars by the use of this gas. The writer must admit that he never saw a gas engine running with greater smoothness than the one operated in this manner.

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RETURNING EXHAUST STEAM TO BOILER

WASTEFULNESS OF THE STEAM ENGINE AS A HEAT MOTOR—WORK REQUIRED TO RETURN EXHAUST STEAM TO BOILER—CONTRARY TO SECOND LAW OF THERMODYNAMICS

AN OLD engineer and subscriber to this magazine writes and compares the steam engine of today and its performance with the engines built when he was an apprentice in Cornwall, more than 60 years ago. He calls attention to the fact that there has been practically no advance during this long period in the vital principles of this great agent of modern civilization. Improvements in details of construction and the use of greater steam pressures have developed higher economies in steam consumption and fitted the steam engine for a wider range of usefulness than was then dreamed of, but theoretically it is still as far from being an ideal heat motor as it was when Watt turned it over to the world. Watt's steam engine has made it possible to achieve results in the construction of machines of all kinds, including its own mechanism, which would otherwise have been impossible, but it still throws away much the greater part of the heat energy supplied to it. No method has ever been devised for making the heat that must be expended in changing water from a liquid to a vapor, under the pressure at which the steam must be discharged from the engine, do work, and unless the steam can be used for heating purposes, all this heat is lost.

These facts lead our correspondent to a speculation regarding the apparent failure of engineers to make any real advance in the principles applied by Watt—principles that involve the loss in the exhaust from the engine of from 80 to 95 per cent. of the heat in the steam it uses. He then inquires why it is not possible to return the exhaust to the boiler where the latent heat of the steam, instead of being wasted, as is now the case, will be utilized. Since this is a question that naturally suggests itself to a thoughtful man who has not given the subject an exhaustive study, it is thought that an attempt to show that such an operation is not only practically but theoretically impossible, will interest many of our readers.

Let us first consider what takes place when heat is made to do work in a steam engine. At the beginning, we have water in the boiler in the form of a liquid without expansive force. On applying heat, at first the principal effect observed is an increase in temperature, a slight change in volume being perceptible. A point is finally reached, however, where the effect of the heat is entirely different. If the water is in an open vessel, exposed to the pressure of the atmosphere, the temperature rises to 212°, after which the effect of applying more heat is to change the water to a vapor, a substance having properties so entirely different from those of the water as to make it nearly impossible to recognize the one in the other. The boiler being open to the air, the water is subjected to the pressure of the atmosphere, 14.7 pounds per square inch, and the vapor has an expansive force that enables it to leave the water against this pressure, while its temperature is the same as that of the water from which it was formed. To change 1 pound of water from a liquid at 212° into this expansive vapor having the same temperature, absorbs as much heat as would be required to change the temperature of 966 pounds of water 1°.

One of the most important effects of the change has been to give the pound of water a volume more than 1,600 times as great as it had before the heat was applied. If, instead of heating the water in the open air, it is heated in the closed space of a steam boiler, the results are somewhat different. The vapor produced, instead of passing off against the constant pressure of the atmosphere, is confined by the boiler walls into a limited space. As the temperature rises, more vapor is crowded into this space, and it is found that a greater pressure than that of the outside air is required to confine it. The application of more heat to the water now has the effect of raising its temperature, and, with each increase in temperature, a little more vapor is forced into the steam space, and a higher pressure is exerted—the force required to confine the vapor and prevent it from expanding and filling a greater space is increased.

Now, let us make this force do work by applying it to the piston of a steam engine. Let the piston in the figure be at the head end of its stroke, as shown by the dotted position *A*, while the pipe *S* connects with the steam space of our boiler. The vapor exerts a pressure on the piston that we will represent by the line *a o*; this

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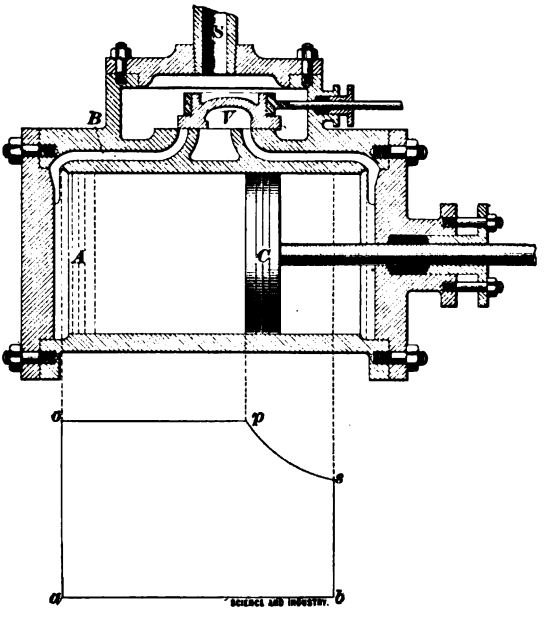
pressure is sufficient to overcome the resistance to the motion of the piston and push it toward the other end of the cylinder. As it moves to the right, the expansive force causes the vapor to flow in from the boiler through the steam pipe and valve, keeps the increasing space at the left of the piston full, and exerts a nearly constant pressure on the piston. This pressure is represented by the distance between the line of no pressure *a b* and the line *o p*, which represents the pressure in the boiler.

During this operation, work has been done; the expansive force developed by the heat that was imparted to the water in the boiler has acted on the moving piston, and, in accordance with the definition of work, the quantity of work done is equal to the product of the force multiplied by the distance through which it has acted on the moving piston.



In order to maintain the constant pressure represented by the distance *a o*, sufficient heat has been applied to the water in the boiler to generate as much steam as has flowed from the boiler to the cylinder. The steam that has left the boiler has been replaced by new steam developed by the action of the heat. The work done on the piston during its motion from the position *A* to the position *C* has required the expenditure of as much heat as was needed to develop the steam in the cylinder. This steam, however, still has a high degree of expansive force that can be utilized and made to do more work. By closing the port *B* by means of the valve *V*, the admission of more steam to the cylinder is prevented. The steam already in the cylinder now acts on the piston and forces it to the right, but, since no more steam is admitted, that already in the cylinder must fill an increasing space; in other words, it expands. As its volume increases, its pressure gradually falls, as is indicated by the curved line *p s* whose distance above *a b* decreases from the point *p* toward the point *s*. During all this expansion period, the steam has exerted a pressure on the moving piston, and, in consequence, it has done work. The quantity of work so done is equal to the mean, or *average*, pressure multiplied by the distance through which it has acted. When the piston reaches the end of its stroke, we have a cylinder full of steam at a pressure represented by *b s*. This steam contains the same quantity of heat that would have been required to change an equal weight of water to steam at the same pressure in a steam boiler, and, by exhausting it into the atmosphere or into a condenser, this heat is lost.

Now, let us make a little study of the results that would follow an attempt to return this cylinder full of steam to the boiler. The first plan that suggests itself for doing this is to use a pump that will take the steam as it leaves the cylinder and force it back into the boiler. In order that all the steam used by our engine may be returned to the boiler, it is evident that the capacity of such a pump must be great enough to return the cylinder full of steam at each stroke of the engine. For the sake of simplicity, let us assume that, at the end of the stroke, the steam cylinder becomes a pump with a check-valve opening into a pipe that leads to the boiler. Instead of exhausting the steam into the atmosphere or into a condenser, this pump forces it back into the boiler.

As the piston moves from its position at the right-hand end of the cylinder, we find that the pressure of the steam in the space at the left increases until it is the same as in the boiler; the check-valve then opens and allows the steam from the cylinder to be forced into the boiler. If there had been no

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loss of heat through the cylinder walls, it would have been found that, for each position of the piston in its motion toward the left, the pressure was exactly the same as it was when the piston was at the same point during its motion to the right. In this process of forcing the cylinder full of steam back into the boiler, therefore, the piston has had to move against the resistance of a force just as great as was exerted on it by the steam while it entered the cylinder. We thus see that this attempt to get the steam back into the boiler will absorb just as much power as the steam developed when it left the boiler. This is the theoretical result. In practice, more power would be required, since the case we have considered neglects the force required to overcome the frictional resistances to the motion of the piston and the flow of the steam through valves and pipes.

It may be argued that we have considered only one of numerous possible methods by means of which the return of the steam might have been accomplished. A little thought, however, will show that we considered the simplest possible method. Any attempt to do the work in a more roundabout way would have resulted only in an increase in the frictional losses and a consequent increase in the difference between the work done by the steam and that required to get it back into the boiler.

It is useful, in connection with the illustration we have just outlined, to consider one of the principles governing the utilization of heat for doing work—a principle that can be proved only by the use of difficult mathematical processes in combination with elaborate experiments. One of the most important of these principles is that known as the Second Law of Thermodynamics, which may be stated thus: *Heat cannot pass from a cold body to a hot body by a self-acting process unaided by external energy.*

In the case of the exhaust from an engine, we have a large quantity of heat in a body (the exhaust steam) whose temperature is lower than that of another body (the steam in the boiler). In accordance with the law, any transfer of the heat from the relatively cool exhaust to the hot water in the boiler will require the expenditure of energy. By permitting the exhaust to give up a large part of its heat to colder bodies, it is possible to utilize a part of it in returning a small fraction of the remainder to the boiler. No method can ever be devised, however, that will make it possible, without the expenditure of more energy than the steam from the boiler can be made to develop, to return all the heat in the exhaust to the boiler.

REPORT OF UNITED STATES NATIONAL MUSEUM

WE HAVE received the report, just published, of the United States National Museum for the year ending June 30, 1897. It is a volume of more than 1,000 pages, besides 80 full-page plates illustrating recent Foraminifera. The report consists of two parts, the first of which relates to the annual work of the museum—its staff, the accessions to its collections, its exchanges of specimens, the materials lent for study or given away, specimens received for identification and report, together with a minute report of the work done in the scientific and administrative departments, and some important appendixes. The second part contains seven papers of very great interest. The longest of these is a paper of about 300 pages on "Pipes and Smoking Customs of the American Aborigines, Based on Material in the United States National Museum."

It is a pity that the American people do not more generally know of the extremely important and valuable work done by this branch of the Smithsonian Institution. It is true that thousands of people in every department of activity in our country are annually the recipients of benefits from the National Museum, but there are many other thousands needing precisely the help —the information—they could get here, who do not even know that such an institution exists.

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REPAIR-SHOP ARMATURE TESTING

Francis H. Doane

APPARATUS REQUIRED—LOCATION OF CROSS-CONNECTED COILS—LOCATION OF SHORT-CIRCUITED COILS—LOCATION OF OPEN-CIRCUITED COILS

LOCATING faults in an armature may sometimes be done by an ordinary inspection without instruments. Many times, however, an armature may look all right, but develops serious trouble when put in the machine and run. A simple and efficient test for locating most of the ills to which an armature is heir, has been in use in several repair shops, and found to be of great value in the work.

The test referred to is known as the "drop of potential" method. An electric current is passed through the coils of an armature by clamping the current terminals to the commutator. The current can be obtained from the line by passing it through some adjustable resistance like a lamp bank or a rheostat, or a storage battery can be used to furnish the current, if one is convenient. If a current of 2 amperes is passed through a coil in an armature having a resistance of .5 ohm, there will be a drop of potential of $2 \times .5 = 1$ volt between the two commutator bars connected to the ends of the coil. Let us suppose that the next coil in the armature is partly short-circuited. Then, as the same current of 2 amperes flows through the coil, and as the resistance of the coil is reduced by the short circuit from .5 ohm to, say, .1 ohm, the drop of potential at the ends of the coil on the commutator bars will be $2 \times .1 = .2$ volt. If the end of a coil, soldered or screwed to a commutator bar, makes poor contact, so as to increase the resistance of the circuit from commutator bar to commutator bar (through the coil), with 2 amperes flowing through the coil and the resistance raised from .5 ohm to .8 ohm, the voltage at the commutator bars will be $2 \times .8 = 1.6$ volts.

A galvanometer or a Weston millivoltmeter, with a scale reading on each side of the zero mark, can be used to measure the voltage between bar and bar of the commutator. If a galvanometer is used, a needle-dampening device must be used to keep the needle from suddenly falling back toward zero when the galvanometer terminals are shifted from bar to bar of the commutator, which, for a small fraction of time, opens the galvanometer circuit at each change of position.

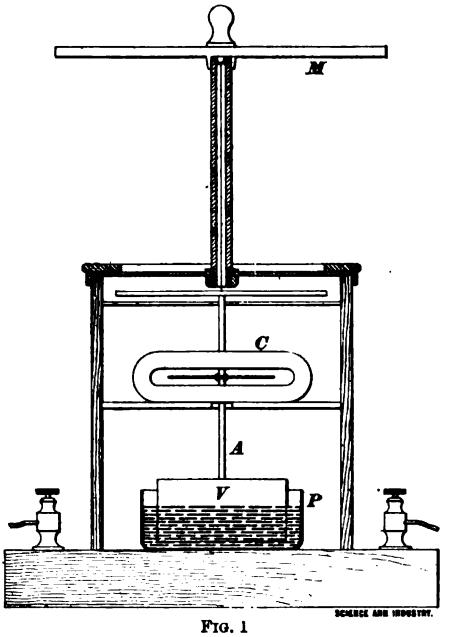

FIG. 1

Fig. 1 shows a galvanometer provided with a damper. *A* is a strip of metal connecting the magnetic needle and the aluminum vane *V*, the vane turning with the movement of the magnetic needle; *C* is the magnetizing coil. The magnetic needle must not be made short and thick, as poles are apt to be set up in it some distance from the extreme ends of the bar, if the current in the galvanometer keeps the same direction and strength for several minutes. The magnetic-bar needle should be long and thin. The vane *V* moves in a pan *P*, partly filled with a very light machine oil. The action of the vane and oil is to prevent sudden movements of the galvanometer needle, caused by opening and breaking the galvanometer circuit. The damper does not prevent the needle from taking up its proper position on the scale, due to the voltage being measured, if a short time is given for the needle to make the change of position caused by variations of voltage at the

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terminals of the coils measured. A bar magnet *M*, Fig. 1, can be used to give direction to the galvanometer needle, so that the position of the instrument can be made independent of the magnetism of the earth.

The connections for the test are shown in Fig. 2. *E* is the line from which the current for the armature is obtained. *L. B.* is a lamp bank. The lamps are mounted on key sockets, so that the resistance of the bank may be adjusted by turning lamps in or out of circuit. The lamps in a bank for 110 volts are all in multiple. For a 220-volt bank the lamps are in sets of two in series across the

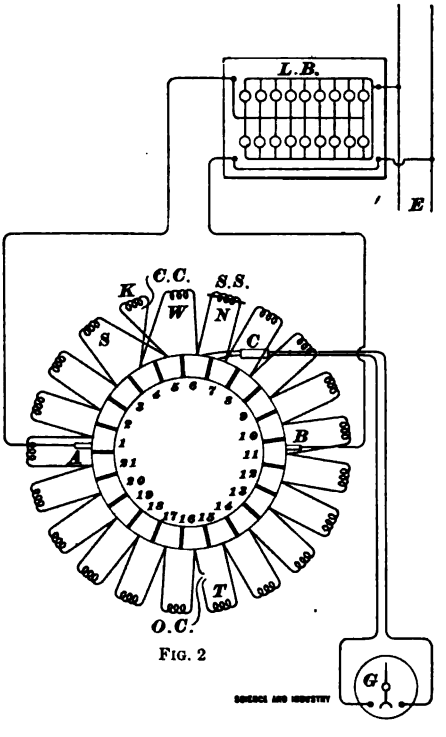

FIG. 2

bank. For a 500-volt bank, groups in multiple of five lamps each in series are used. The commutator bars are shown numbered from 1 to 21. The coils of the armature are represented just above the commutator bars, and connected to them by the armature leads. *G* is the galvanometer or millivoltmeter, connected to the crab *C*; *A* and *B* are the connectors to the commutators for the current from the lamp bank; *C. C.* is a cross-connection of the armature leads of coil *K*; *S. S.* is a short circuit of the coil *N* connected between commutator bars *6* and *7*. *O. C.* is an open circuit in one lead of the coil *T*, connected to commutator bars *15* and *16*. The two spring legs of crab *C* bear on adjacent bars of the commutator, and serve to convey current to the galvanometer *G*.

Fig. 3 represents a simple form of strap clamp for the current terminals. A narrow band of webbing passes through a hole in each terminal and through a length-adjustment buckle. Another device for the same purpose is made by mounting the terminals on an adjustable clamp and hanging the clamp on the commutator.

The operation of the test is as follows: Apply the terminals to the commutator and adjust the resistance of the lamp bank until the galvanometer needle has a throw of proper amplitude, say from 30° to 80°, when the crab is on what are supposed to be good bars. If the armature is a high-resistance one, the necessary current from the lamp bank will be small. If the armature resistance is small, a large current will be necessary. The operator must determine what the value of the standard deflection is for the armature being measured. He runs over several bars and gets, perhaps, a deflection of 45°. He calls this his standard, and compares the deflection from the other bars with it. In case he should start in on the damaged part of the armature, he would find, when he came to the good coils, a difference in deflection. It is usually easy, however, to determine what the standard deflection for the armature should be. If the start is made near the terminal *A*, and a deflection of 45° is obtained, then the deflection from bar *1* to bar *2* and from bar *2* to bar *3* will be 45°. From bar *3* to bar *4* a high deflection, say of 65°, will be found; from bar *4* to bar *5* a reversal of direction of throw of the galvanometer needle to —45° will take place, and from bar *5* to bar *6* will be found a deflection of +65°, the same as found between bar *3* and bar *4*.

From Fig. 2 it is seen that when the crab is on bar *3* and bar *4*, the galvanometer measures the voltage of coils *S* and *K* in series, which, since the current on that side of the armature is constant, gives a deflection due to the voltage caused by the current times twice the resistance of one coil. On the galvanometer this might be represented by 65°. If the millivoltmeter is used, the reading will be twice the number of volts for one coil. The direction of the throw of the galvanometer needle will be reversed when the crab is on bars *4–5*, due to the leads of coils *S*, *K*, and *W* being crossed. Between bar *5* and bar *6* a similar effect to that between

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bar *3* and bar *4* will be noted. This is for the same cause, as the voltage of *K* and *W* in series will now be measured. When the crab is moved to bars *6* and *7*, connecting with the

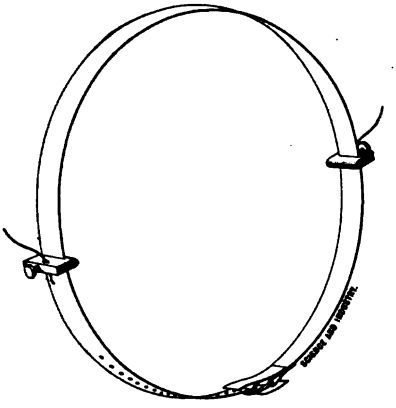

FIG. 3

short-circuited coil *N*, the galvanometer will show but a slight, if any, reading, since the drop of potential between bars *6* and *7* is very small, due to the low-resistance path for the armature current, from bar to bar, through the point of short circuit. At *7–8*, *8–9*, *9–10*, and *10–11* the standard reading of the galvanometer will be found. When the crab gets below the current terminal *B*, no reading of the galvanometer takes place, as current does not flow around that side of the armature, due to the open circuit of one lead of the coil *T*. When the crab, moving from *B* toward coil *T*, rests on bars *15–16*, the galvanometer needle is violently moved, as the galvanometer is now in series with all the good coils from *A* to *B*, and is connected across the terminals of the open-circuited coil *T*. This allows all the current flowing from *B* to *A* on the lower side of the armature to flow through the galvanometer. This current is usually of sufficient strength to destroy the galvanometer coil if it is left in circuit for any length of time. When the crab moves to bars *16–17*, no deflection of the galvanometer takes place, as the path of the current on the lower side of the armature is open-circuited at *O. C.* For the same reason, no deflection will be obtained until the crab moves above the current terminal *A*.

Bars *15* and *16* may be connected together by a short wire; current will then flow around the lower part of the armature, and the coils on that portion may be tested for a short circuit, crossed connections, and other troubles, in a similar manner to the method employed on the upper part of the armature. In case the galvanometer is connected between two bars, where a reading 20° or 30° higher than the standard reading is noted, it is probable that the coil leads to the commutator bars are not properly soldered in. The increased resistance at that point gives a higher reading on the galvanometer. In case one coil is short-circuited to a coil several coils distant, slight, if any, deflection will be noted on the galvanometer, when the crab is passing over the bars between the two sets of bars to which the two injured coils are connected. The greater part of the current will take the short-circuit path from one short-circuited coil to the other.

When a galvanometer of the kind described is used, it is not suitable for portable work outside of the shop. For hasty testing on outside work, a few cells of primary battery may be substituted for the line and lamp bank, and a telephone receiver in place of the galvanometer. Apply the current from the battery to the commutator in the usual manner. Take the terminals from the receiver, hold one on a bar of the commutator and keep tapping the adjacent bar with the other terminal. If any of the armature coils are short-circuited, open-circuited, etc., the volume of sound given out by the telephone receiver will vary. Reversal of connections can only be detected by increased sound on the bars just before and after the bars to which the reversed coil leads are connected. A magnetic or mechanical circuit interrupter can be placed in the telephone-receiver circuit. In case this is done, both terminals are held solidly against the two commutator bars. The interrupter breaks the circuit. Do not put the interrupter in the battery-armature circuit, because the effects of induction in the coils of the armature will make it impossible to determine, with any accuracy, the location of the injured coils.

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HUMAN HABITATIONS

A Liberal Translation by Mary E. Mitchell From the French of C. Fontaine

GREAT progress has been made since the time when man constructed the first hut until this age with its towering buildings, wherein water, steam, and electricity are all employed for his convenience. Let us examine this progress and see what a step it is from that time until now.

Man is led by instinct to defend himself against assault, and to protect himself from the elements. In the most ancient time recorded in history, man sheltered himself under ledges and defended himself from his enemies by raising barriers of earth or rocks. With these needs of shelter and defense, finally arose the desire to make them as attractive as possible by use of ornamental features and pleasing forms. So it is that the customs of the people and their artistic sentiments are the two points of departure from all the modifications that man has employed from age to age in the construction of his dwelling.

In the district of the Yonne, in the vicinity of Joigny, France, the site of a great number of houses, relics of the stone age, can be seen. These areas are circular spaces having a diameter of from 8 to 10 meters, their center being occupied by the trunk of a fossil tree, around the base of which the ground is of black earth and grass mixed with coal, flint, and, in many instances, the bones of the ancient inhabitants.

Traces of these first human societies have been found in France, along the valley of the Oise; have been located in England; near Madrid, at San Isidro; in Italy; in Egypt; in Algiers; and even in the Great Sahara, which at that time was watered by majestic rivers and nourished a numerous population. Evidence of such early habitations has also been found in Palestine and in Syria, as well as in Asia and Mexico. On the pampas, those infinite plains of South America without rock and trees, man, for the want of better shelter, installed himself under the carapace of the gigantic armadillo, the spoils of the conquered animal becoming the home of the conqueror.

About the time man invented the first tools, he became imbued with the desire for a habitation of greater security, and chose what nature offered him—some grotto of difficult access. The dwelling became a fortress, at first a natural one, though later, as his resources developed, he conceived the idea of making for himself artificial fortifications. The explorer Nachtigal has described, in an account of one of his voyages, an aerial village in Soudan consisting of houses built in the trees. These primitive habitations of man rested upon the largest branches, which are nearly horizontal; these branches were tied together and joined to the transverse branches by knots of liana. Such dwellings as those were free from danger of attack, as all connections with the ground could be quickly cut off.

The Paeonians of Thrace, says Herodotus, built their villages upon stakes driven into the bottom of a lake, and, according to Hippocrates, the people living east of the Black Sea, on the River Phasis, elevated their cabins on reeds rising from the middle of the river. In our day, the Malays and the Chinese living in Bangkok, the natives of New Guiana, as well as some of the inhabitants of the island of Mindanao, construct their houses on stakes driven into the beds of the streams; and Burton, the English voyager, made famous by his discovery of Lake Tanganyika, in 1858, has observed similar habitations in Dahomey and Cameron and also in Central Africa. When the Spaniards discovered the lagoon of Maracaibo, in South America, they saw there a village erected on stakes, "a little Venice of wood," to which Venezuela owes its name.

It has long been known that a considerable population had lived in prehistoric cities located in the lakes of Switzerland. Twenty of these lake cities have been found on the Lake of Bienne, twenty-four on the Lake of Geneva, thirty-two on Constance Lake, and forty-nine on the Lake of Neuchâtel, while traces of similar cities have been discovered in France, Italy, Germany, England, Scotland, Ireland, Austria, and Hungary.

The lake man, when he became a dweller on the land, copied the habitations in which he had lived so long, and constructed his hut of branches covered with petrified clay or with the skins of animals. These first buildings were rounded off at the summit and often elongated, in order to increase the space at the disposition of the inhabitants. After a while, however, he learned to place stones one over another and to garnish the interstices with flint, then to join them with clay, and finally with the more resisting cement. The walls of these stone huts or

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hovels were raised waist high, and upon them rested the roof beams, having the necessary slope to shed the water, while transversing these beams were placed interlacing branches or sod.

Admittance into these dwellings could only be had by crawling, and the interior offered anything but comfort. The soil was extremely hard, and the seats consisted of flat elevated stones or benches of stone jutting from the wall, these benches also serving, without doubt, for beds. The walls of these habitations were usually strengthened by the use of an outside wall of dry stones. Auvergne, with its volcanic and megalithic cities, and Scotland, with its earth houses, show the most curious specimens of this domestic architecture.

From the time when man learned the art of constructing walls, his habitations were rapidly perfected. Houses of stone were the first that he built, because, from the first ages of humanity, he learned to work stone. Soon he began to make and use bricks, and, little by little, as ideas of health and hygiene came to him, he conceived the idea of leaving a large space between the ground and the floor, and built a second story above the first, making openings in the walls through which air and light could penetrate.

It was reserved for the present epoch, however, to substitute iron for stone in our large buildings, and it was also reserved for us, alas! to construct buildings twenty stories high, which, while they are provided with all possible conveniences, can never be graceful. Those masters of architecture, the Greeks, fortunately never reached what might be called the age of utility, and their monuments have remained to this day the ideal of elegance and, in consequence, good taste. We live, it is true, in a century when the beautiful ought to yield to the useful; but can we not hope that a day will come when we will forget somewhat our love of money and senseless luxury, to return to the worship of the beautiful?

POSTAL-CHECK CURRENCY

ONE of the great needs of rural communities and small towns having no banking facilities or money-order post office, is some means by which small sums of money may safely be sent through the mails. Nor is this inconvenience felt by small communities only, for, in large towns and cities with adequate money-order and banking facilities, it is often very inconvenient to get a money order or check, and, in consequence, the sending of stamps is often resorted to for the payment of small amounts.

The disposal of the large aggregate sums in the shape of stamps received by publishers of periodicals and by others whose receipts are largely in small amounts from widely scattered sources, has become a serious problem with business men. One large publishing house in Chicago reports an annual receipt of $350,000 in postage stamps, and the same inconvenience is experienced by business houses all over the country, on a greater or less scale.

A bill now before congress proposes to remedy this defect in the postal service by reprinting all $1.00, $2.00, and $5.00 bills and provide blank spaces on the face of them, which may be filled out the same as a check. It is also proposed to authorize an issue of $50,000,000 in fractional bills of the post-check form, in denominations of 5, 10, 15, 25, and 50 cents, in place of the same amount of large notes now in circulation. These small bills are to be of the convenient form of fractional currency adopted during the Civil War, but to have the blank spaces to be filled out. They are to pass as currency so long as the blank lines are not filled in, but when it is desired to send a small amount of money through the mails, any bill is transformed into a check on the United States Government by filling in the blank spaces and affixing a stamp, and it can then be collected by the payee or deposited in the bank the same as any other check. When a bill has thus been changed into a check and been paid, it is canceled and a new bill of like denomination issued in its stead, which insures a clean currency and removes the sanitary objection to the present bills.

The proposed currency law has met the approval of high post-office and other government officials, and seems to be one that will meet the requirements of the public. Those interested in the matter may greatly aid in the passage of this measure by urging their representatives in congress to give it due consideration.

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PORTLAND CEMENT

Geo. H. Waltman

DIFFERENCE BETWEEN IT AND NATURAL CEMENT—OLD AND NEW METHODS OF MANUFACTURE—REQUIREMENTS OF CEMENTS

THE cement industry began in England, where the principal works are located on the Thames and Medway Rivers. It then spread to Germany and Belgium, thence to the other European nations, and finally to this country, where, after a modest beginning, it has finally developed into an industry of enormous proportions; and, notwithstanding the increasing number of new mills and enlarged dimensions of old ones, the supply is unable to keep pace with the demand, on account of the new uses to which it is constantly put.

Some years ago cement was only used to line cisterns, and occasionally for cellar floors. Sidewalks made from it were a luxury; but now, on account of its economy and durability, cement is rapidly superseding all other materials for this purpose. It is also extensively used for window sills and floors in fireproof buildings. Foundations are generally made of it in the form of concrete, which is only another name for a mixture of cement, sand, and broken stone. It is also making its way as a material for constructing walls, the bodies of which are of concrete and the outer surfaces of smooth cement and sand, sometimes formed to imitate hewn stonework.

Cement is of two classes, viz., Portland cement and natural cement. The latter is made of impure limestone, which contains, in a greater or less degree, the necessary constituents for making cement. These constituents have been mixed by nature, and for cement making must be used in the proportions in which they are found. With Portland cement, however, nothing is left to chance, as it is known, by constant analysis, what the constituents should be and in what proportions they should appear in order to obtain the best results. It is, therefore, within our power to make a Portland cement from a mixture of cement rock and limestone, clay and limestone, marl and clay, or marl and limestone.

An ideal Portland cement should possess the following composition:

Lime	62.2%
Silica	28.2%
Alumina	9.6%

However, a third of the alumina may be replaced by ferric oxide, and the cement would then correspond to the following composition:

Lime	61.7%
Silica	27.4%
Alumina	7.5%
Ferric oxide	3.4%

The actual analysis, however, of the Portland cement, as supplied to the trade, approaches these figures in about the following proportions:

	Maximum.	*Minimum.*
Lime	62.0%	57.0%
Silica	24.0%	19.0%
Alumina	8.8%	5.2%
Ferric oxide	5.0%	2.0%
Magnesia	3.5%	0.3%
Potash	1.0%	0.4%
Soda	0.8%	0.4%
Sulphuric acid	1.0%	.....
Sand, etc.	2.9%	1.0%
Carbonic acid	1.9%	.....
Water	1.5%	.....

Portland cement is much superior to natural cement, as the best natural cement never attains the hardness nor does it have the strength or durability of the most ordinary Portland cement, which, in a general way, differs from natural cement by being heavier, slower in setting, and stronger.

Portland cement derives its name from the resemblance that hardened mortar made of it bears to a stone found in the Isle of Portland, off the south coast of England. The modern method of manufacturing it is as follows: After the stone has been quarried and conveyed to the works, it is crushed and pulverized in proper proportions; it then enters a long horizontal revolving cylinder, made of steel plates riveted together and lined with firebrick—commonly known as a *rotary kiln*. At the opposite end, called the *burning* end, an intensely hot flame is forced into the kiln, by means of a blast created by a blower or an air compressor. The flame is sometimes produced by the combustion of producer gas or petroleum, but pulverized coal is most generally used, owing to its cheapness and ease of manipulation.

The pulverized raw stone is fed in a continuous stream into the opposite end of the kiln, known as the *feed* end, and by reason of the slight inclination of the kiln, together with its rotary motion, the cement material

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moves onwards in an opposite direction to that of the flame. In its passage through the furnace, the material gets hotter and hotter, until it reaches the zone of greatest heat, when the particles begin to adhere to each other and finally become a mass of clinkers, irregular in shape and size. These hot clinkers are either allowed to fall upon a floor of fireproof material or to pass onwards through another rotary shell to cool. During this process of calcination the carbonic acid is separated from the cement material, and escapes through a stack to the atmosphere.

The amount of material under treatment at one time inside the kiln does not exceed three or four tons. The operation is very rapid, taking no more than half an hour from the time the raw cement material is fed into the kiln until it comes out as clinkers. There is no interruption in the feed or in the output, but on account of the loss in evaporated water and carbonic acid, only about two-thirds of the weight of the material fed in will come out as burnt cement.

The clinkers of the rotary kiln have a very different appearance from those of any other kiln. They are like irregularly rounded balls, from the size of a grain of wheat to that of a man's fist, and are somewhat porous in texture—tougher, but more brittle, than in their original condition.

An experienced cement burner can always detect any irregularities in the quality of the cement he is burning by the appearance of the clinkers after they are cold. The presence of many sparkling crystals on a dark-colored and heavy clinker shows an excess of lime; a deficiency of lime would be indicated by a brown-colored clinker with fused spots.

After the clinkers have sufficiently cooled, they are reduced in a crushing roll to a uniform size, and are then taken to a pulverizing mill, which further reduces them to about the consistency of flour, or, as it is technically termed, so that it will pass through a 10,000-mesh sieve. These pulverized clinkers are now what is commonly known to the trade as Portland cement, and ready for the market, after mixing with it a small amount of plaster of Paris, which regulates the setting quality of the cement mortar. It is then packed in paper or canvas bags or in barrels.

Some manufacturers and consumers prefer having their cement "aged," or stored for a period of time before being used. This is of advantage to those preferring a slow-setting cement, since usually the older a Portland cement is the slower it is in setting, provided it has been properly stored. The Portland cements are usually what are termed "slow setting," while the light-burned natural cements are "quick setting." This property may, in some cases, settle the question as to which cement should be used. In the case of dams, retaining walls, and foundations, a slow-setting cement may be used to advantage; while for bricklaying, pointing, or plastering, a quick-setting cement is best adapted. In all cases during the process of setting, moisture adds greatly to its final strength and durability.

The foregoing account of cement making is, as was previously stated, the modern method, but it must be understood that it is not the only method. Though the adoption of the rotary system is rapidly gaining favor among cement manufacturers, who are now installing rotary kilns in place of the old-style vertical kilns, it is but a short time since these vertical kilns were the only means for making all cement, and, though they are fast disappearing, their prominence in cement history make them still an object of passing interest.

The earliest type of these kilns was what is known as the *dome kiln;* and, while there have been many changes in some of the details of these kilns, the essential features remain unchanged. When the kiln is cold, kindling and light fuel are put in on the grate bars. On top of this is placed a heavy layer of coal, then a layer of stone, or pulverized material moistened and molded in irregular blocks or bricks, repeating the layers of coal or coke and stone until a sufficient amount of material is in the kiln. The fire is started at the bottom and burns upwards, slowly but gradually heating the whole mass until the kiln becomes hot. The first action of the heat is to drive any remaining moisture from the mass. A moderate temperature only is needed for this. As more fuel ignites and the fire approaches the stone, the temperature increases until it begins to act on the carbonic acid. During the first stage an invisible vapor is driven off; when the mass has become heated to a good red heat, carbonic-acid gas is driven off. When this has been accomplished and the whole mass raised to a white heat, the third and last stage begins, which is the fusing together of the cement-making materials. At this point the uncertainty of burning by this process is made apparent. The product may be overburned, underburned, or correctly burned, but which of these results is attained

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depends on the proper proportioning of the fuel and stone. As the fuel is consumed the clinkers sink to the bottom and are removed, fresh fuel and stone being added at the top. In this way the process can be made more or less continuous. Under other circumstances the kiln is charged and the entire mass burned, when the kiln is allowed to cool and the clinkers are removed.

The disadvantages of this process are that the relative amounts of fuel and stone must be decided on before the burning commences, and once the kiln is started the amount of fuel cannot be changed. The relative amount of fuel necessary depends on the character of the fuel, the character of the stone, the shape and height of the kiln, the temperature, the humidity of the atmosphere, and the direction and force of the wind.

As will be seen, many of these conditions, under the dome-kiln system, are entirely beyond the control of the cement maker, and are liable to change at any time during the burning. On the other hand, in the rotary-kiln process, the necessary conditions to be fulfilled are entirely under the control of the man in charge.

However, even with this improved process, there still remain obstacles to the economical production of cement. Among these may be mentioned the heat lost by radiation and by escape through the stack under forced draft, with the consequent unnecessary expenditure of fuel. Another is the clinkering of the material during burning, necessitating crushing and pulverizing.

Cement is standardized according to its fineness and the time it requires to set or harden; also by its tensile strength per square inch of section, and by its expanding and contracting qualities while setting.

The following tables will show the average American requirements for fineness and strength of Portland cement and natural cement:

PORTLAND CEMENT

Per cent. of cement passing sieve: No. 50, 95%; No. 100, 84%.

	Neat Cement.			Mortar.			
				1 Part Cement, 2 Parts Sand.		1 Part Cement, 3 Parts Sand.	
Age in Days When Tested.	1	7	28	7	28	7	28
Tensile Strength in Lb. per Sq. In.	131	402	547	150	200	119	189

NATURAL CEMENT

Per cent. of cement passing sieve: No. 50, 91%; No. 100, 72%.

	Neat Cement.			1 Part Cement, 2 Parts Sand.	
Age in Days When Tested.	1	7	28	7	28
Tensile Strength in Lb. per Sq. In.	38	102	164	34	77

TREATMENT OF INCANDESCENT LAMP FILAMENTS

WHEN incandescent lamps were made with carbonized bamboo filaments it was impossible to get them of uniform resistance throughout. The result was that, when a current was sent through the lamp, the filament glowed more brightly in some spots than in others, and in order to make the resistance uniform the filaments had to be "treated." This treatment consisted in introducing a hydrocarbon gas into the bulb and then sending current through the filament. The parts that glowed brightest, i. e., those that were of too high resistance, had carbon deposited on them more rapidly than on the cooler portions, which brought the filament to a uniform resistance throughout.

Filaments are now manufactured from cellulose by means of the squirting process, and there is no difficulty in making them of uniform resistance, but the treatment is still continued, not because it is necessary to secure uniform resistance, but because it has been found that the hard coating of graphitic carbon given to the filament by this process greatly improves its light-giving properties. The untreated carbon radiates its heat much more readily than the treated, hence a given amount of power expended in the lamp will cause the treated carbon to attain a higher temperature than the untreated, and the efficiency of the lamp is thereby improved.

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SIMULTANEOUS TELEGRAPHY AND TELEPHONY

H. S. Webb, M. S.

SOME PRINCIPLES INVOLVED—HOW TELEGRAPH CURRENTS ARE PREVENTED FROM AFFECTING THE TELEPHONE—COMPLETE DIAGRAM OF CONNECTIONS

THE transmission of telegraph and telephone messages over the same wire at the same time is called *simultaneous* telegraphy and telephony. Before describing the methods of arranging the telegraph and telephone apparatus by which this simultaneous transmission can be accomplished, it will be well to consider briefly some of the fundamental principles involved.

One of the difficulties to be overcome in attempting to telegraph and telephone simultaneously over the same wire is that the telegraphic signals would, without special precautions or arrangement of apparatus, be heard in the telephone receivers. This would cause a great deal of annoyance, and the telegraph messages would not then be secret. The wasting of the telephone currents in the telegraph instrument must also be avoided.

In a simple short telegraph circuit, the current will rise to its maximum value almost instantly when the key is closed and fall to zero almost instantly when the key is opened. A curve representing the current in such a circuit is about as shown in Fig. 1, the time in seconds being laid off along $O\,Y$, and the corresponding current in amperes along $O\,X$. The time required for the current to reach its maximum value, even on an overhead line of 350 miles in length, is ordinarily less than one-fortieth the time required to make a dot. In telegraphing at the rate of 25 words a minute, which is equivalent to about 5 Morse signals a second, there would be, if means were not taken to avoid it, 10 intense clicks every second in a telephone receiver connected between the line wire and the ground, one of these being made every time the telegraph key was closed and another every time it was opened, due to the very rapid rise and fall of the relatively large telegraph current, which is about 100 times larger than the telephone current. If the telegraph current can be made to rise and fall gradually enough, the telephone receiver will not make any click. The accomplishment of this has made possible one method of simultaneously telephoning and telegraphing over the same wire.

It is a well-known fact that the sudden rise and fall of a current in a circuit can be delayed, that is, made more gradual, by increasing the inductance in the circuit. Furthermore, if in addition to the inductance coil a condenser is connected from the line to the ground, the current in the line will rise and fall still more slowly. Hence, by using enough inductance coils and condensers, the current in the line may be made to rise and fall as slowly as desired. A simple telegraph circuit, with two inductance coils I and I_1, and two condensers C and C_1, connected in the circuit, is shown in Fig. 2.

The coils I and I_1 are called *impedance*, *retardation*, or *choke* coils, and are usually made by winding a large number of turns of insulated copper wire over a soft-iron

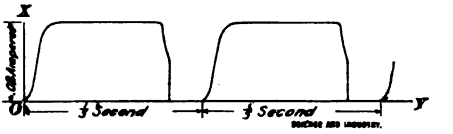

FIG. 1

wire core, the ends of the iron wire being brought together and overlapped, as shown in Fig. 3, so as to form a closed iron circuit for the magnetic lines of force. With a given number of turns of insulated copper wire and a given cross-section of iron, such a closed magnetic circuit will give a maximum inductance, causing a maximum opposition to a rapid rise or fall of the current. In making such a coil, it is of much more importance to have a large number of turns of copper wire and a good magnetic circuit of iron than to have a large resistance. In fact, the smaller the simple resistance can be kept the better, provided there are a large number of turns. Low resistance and a large number of turns means a large coil, because large-sized copper wire must be used, and it becomes necessary to compromise in order to have neither too large a coil

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nor too high a resistance with a given number of turns.

Suppose that in Fig. 2 the key K is closed. The inductance of the relay R and the impedance coil I will act as a barrier to the inrushing current and will prevent it from attaining its maximum strength as quickly as it would were the impedence coil I not in the circuit. The greater the inductance in the circuit, the slower will the current increase and decrease. Furthermore, the condenser C must be fully charged before the current in the line can reach its maximum value. As fast as the current is able to get through the relay R, it first tends to charge the condenser C, and, as the condenser becomes more and more nearly charged to its full capacity, more current will flow through the coil I, which also impedes its rapid increase. The increase in the strength of the current in the line wire is thus made to take place more slowly than it would without the condenser and the impedance coil.

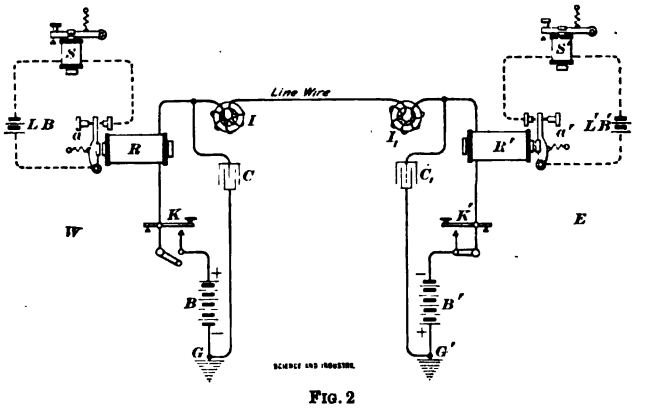

FIG. 2

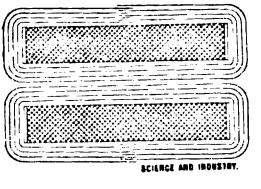

FIG. 3

On opening the key K, the condenser C tends to discharge its current through the coil I into the line in the direction of the original current, thereby tending to prolong the current in the line and causing it to decrease more gradually. The combination of condensers and impedance coils thus opposes any rapid change in the strength of the current, and the current curve can be made to approach that shown in Fig. 4 by using the proper amount of inductance and capacity.

At the rate of 25 words a minute, there would be about 5 dots and spaces, or 5 curves like the one shown in Fig. 4, a second. The induction coils and condensers will interfere with telegraphing at a high speed, and especially with rapid automatic systems, because the signals would be of such a short duration that there would not be time for the current to rise or fall through a sufficient range to properly operate the relays. Moreover, even if suitable relays or other instruments could be used, such rapid signaling would interfere with what we are striving for, namely, to telephone as well as to telegraph over the same line. About the lowest audible sound is produced by 16 complete vibrations per second. Therefore, an undulating current that changes at such a low rate that it would never cause the diaphragm of a telephone receiver to move as fast as it would be moved by a current having a frequency of 16 periods per second, would produce no sound, not even a single click, in the receiver.

Now, if a telephone receiver TR and the secondary winding of the induction coil s were connected between the line and the ground, as in Fig. 5, but without the condenser C, more or less of the telegraph current would go through the receiver circuit to the ground in preference to passing through the line and the distant office instruments.

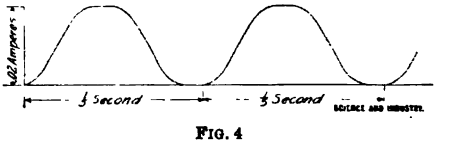

FIG. 4

Even if this current produced no sound in the receiver, it would still be necessary (in order that the telegraph signal made at the sending station shall affect the relay at the receiving station) to prevent the flow or leaking of the telegraph current through the receiver. To accomplish this, the condenser C_2 is connected between the receiver and the line. The condenser will not allow a continuous current to pass through it, because its resistance to such a current is practically infinite. Since the condenser

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charges and discharges very slowly when telegraph signals are being sent, thereby causing the receiver diaphragm to move in and out very slowly, the rate of change of the current in the receiver is not great enough to cause an audible sound.

It has now been shown that the telegraph signals do not affect the telephone receivers. It yet remains to be shown that the telephone currents sent from one end will operate the telephone at the other end but will not interfere with the telegraph signals sent from either end. In ordinary conversation, the average frequency of the sound waves is at least 300 complete vibrations, or periods, per second. By talking into a telephone transmitter, therefore, an alternating electromotive force is generated in the secondary winding of the induction coil, the average frequency of which is at least 300 periods per second. This rapidly alternating electromotive force will charge and discharge the condenser C_2, which will produce in the line wire an alternating current similar to that in the ordinary telephone line. In Fig. 6 is represented a current wave such as might be produced in the line

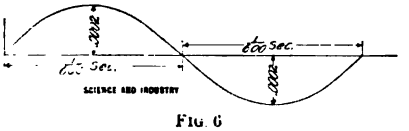

FIG. 6

wire by the simplest sound waves having a frequency of 300 periods per second. Let the curve *A* in Fig. 7 represent the slowly increasing and decreasing telegraph current, and the curve *B* the rapid alternating telephone current. In the line, these two will be superimposed on each other, producing a resultant curve of the form shown at *C*.

When both the telephone and telegraph are in operation simultaneously, the telegraph current causes the diaphragm of the receiver to move in and out through a relatively large amplitude, but too slowly to make any sound. At the same time, it will vibrate very rapidly through a very small amplitude, because the telegraph current will have its strength very rapidly but very minutely increased and decreased by the telephone current. It is enough, nevertheless, to increase and decrease the pull of the magnet on the diaphragm sufficiently to produce sound waves. One vibration is thus superimposed on the other, and the diaphragm vibrates, or trembles, very rapidly as it moves slowly in and out as the telegraph current slowly increases and decreases, and it reproduces the words spoken at the distant transmitter, but the telegraph

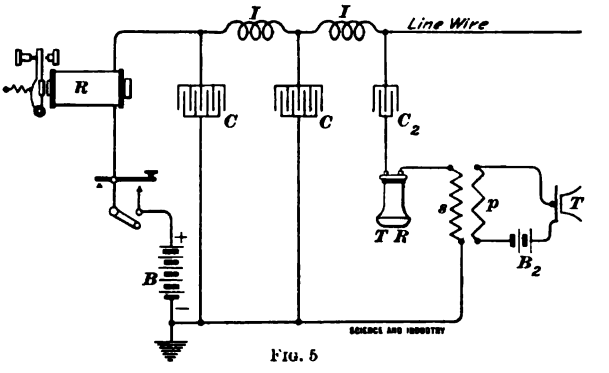

FIG. 5

current, however, produces no sound. The question might arise as to why the telephone current does not go to the ground through the telegraph apparatus at the end where it is generated and interfere with the telegraph signals, instead of flowing through the long line wire to the distant telephone. In the first place, even if all the telephone current did go through the home telegraph apparatus, it would not affect the signals, for the telephone current is probably less than $\frac{1}{100}$ as large as the telegraph current, and its effect on the relay would not be apparent, as is evident from curve *C*, Fig. 7. Moreover, practically the whole telephone current will go over the line and through the distant receiver,

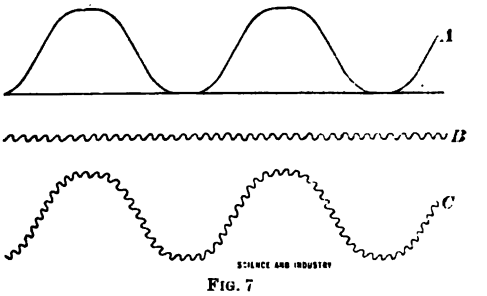

FIG. 7

for the following reason: It is a well-established fact that a circuit containing inductance offers more opposition, or *impedance*, as it is called, to the flow of an alternating current than the simple resistance with which it opposes a direct current, and

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this opposition increases very rapidly as the frequency increases. For instance, a certain impedance coil, with a resistance of 500 ohms and an inductance of 8 henrys (for a current of .013 ampere), offers an impedance of 15,128 ohms to an alternating current whose frequency is 300 periods per second. This impedance is over 30 times as large as the simple resistance.

The impedance of the ordinary 250-ohm secondary coil may be as much as 4 times its resistance, but the condenser in series with it tends to reduce the impedance of this circuit, and consequently the impedance of the telephone circuit, including the receiver, the secondary coil, and the condenser, is probably not over 1,000 ohms. An induction coil having a lower resistance secondary would be better in this case. In circuit with the impedance coil there is also the relay, so that the total impedance of the apparatus at one end of the line circuit shown in Fig. 2 is probably more than 50 times as great as that of one receiver circuit. To insure more satisfactory results, two impedance coils and two condensers are generally employed at each end, as shown in Fig. 5, thus compelling practically all the telephone current to pass through the line and the distant telephone circuit, because the latter offers so much less opposition to its passage than the impedance coils and relays.

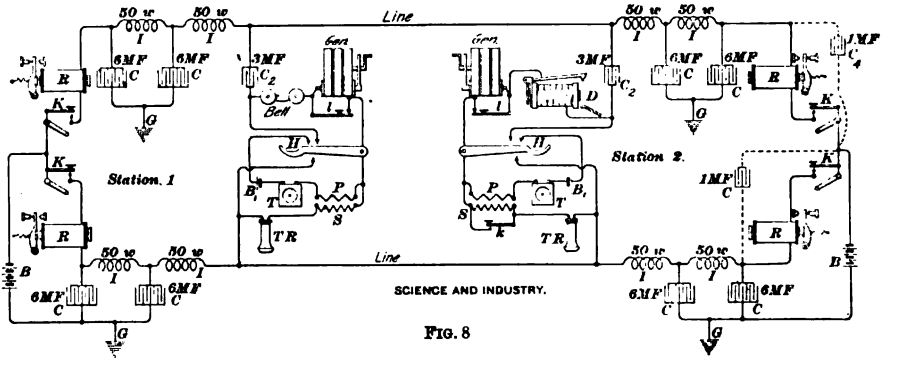

FIG. 8

The complete arrangement of the telegraph and telephone apparatus is shown in Fig. 8. It is sometimes advantageous to connect a condenser of 1 or 2 microfarads capacity around the telegraph key and relay, as shown by the dotted lines at station *2*.

This figure gives a complete diagram of connections for one complete metallic telephone circuit and two telegraph circuits over one pair of line wires, the ground being used as a return for the two telegraph circuits. If a complete closed magnetic circuit of good soft iron is used for the impedance coils, enough turns of insulated copper wire to make 50 ohms have been found to be sufficient for each coil. The condenser in the telephone circuit has a capacity of 3 microfarads; those from one side of the impedance coils to the ground have a capacity of 6 microfarads. If desirable, an ordinary telephone annunciator may be used, as shown at *D*, station *2*, in place of the bell shown at station *1*, and a push button *k* may be arranged, as shown at station *2*, to short-circuit the secondary winding *S* of the induction coil while listening. The push button *k* must be released while talking. This push button is not desirable, because, if it is held closed while talking, the party listening at the other end can hear nothing. However, it may improve the working enough to warrant its use.

The push *l* is arranged to normally short-circuit the generator armature to cut its resistance out of the circuit. When the generator handle is turned to call up the distant station, this push button should be pressed, in order to open the short circuit around the generator. Most generators have an automatic device that accomplishes the same purpose when the handle of the generator is turned. *H* is the ordinary hook switch. When the receiver is on the hook, the bell and generator are connected across the two line wires through the condenser C_2, the circuit containing the primary winding *P* of the induction coil, the transmitter *T*, and the transmitter battery B_1 is open, and the circuit containing the receiver *TR* and the secondary winding *S* is short-circuited. When the receiver is removed from the hook, the bell and generator are short-circuited, the local transmitter circuit is closed, and the short circuit around

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the receiver and secondary is opened, leaving this latter circuit across the two line wires through the condenser C_2.

This method for the simultaneous transmission of telephone and telegraph messages over the same line was originated and developed by Van Rysselberghe, an official of the Belgian telegraph service, and is known as the *Van Rysselberghe method*. It is now being used both in Europe and in this country.

CONSTRUCTING A SHEET-METAL CUPOLA

William Neubecker

DESCRIPTION OF THE WORK—EXAMINATION OF THE DRAWINGS—LOCATING THE SEAMS. LAYING OUT THE MITER FOR THE OCTAGONAL BASE MOLD

THE writer will endeavor to explain, in this article, the methods employed in the construction of a sheet-metal cupola, from the time the architect's scale drawing is received until the work is in place on the building.

The first step is to thoroughly study the design, so that we may know where the seams had best be placed, what portions should be finished complete in the shop, and how the seams and joints may be constructed in order that they can easily be joined or soldered at the building. Too much stress cannot be laid upon these considerations, for when the work has been carelessly laid out, the joints are apt to come in such positions that it is difficult to join or solder efficiently, while a little foresight exercised in locating the seams would have avoided the trouble and loss of time.

Let the design shown in Fig. 1 be the ¼-inch rendered drawing as we have received it from the architect. By studying the drawing, we decide that, in order to make a good job and obtain workable joints at the building, it will be necessary for us to locate the building joints at *E*, *F*, *G*, *H*, and *I*; and that we will finish the various sections in the shop as follows: The base *J*, in two parts; the columns *K*, *K*, *K*, etc., complete; the cornice *L*, in two parts; the paneled soffit *M* of the cornice, complete; the dome *N*, to be constructed over the sheathing at the building; the ribs *O* of the dome, in two parts; the lantern *P* and the cross *R*, complete. The floor *S* of the cupola will be placed over the sheathing at the building.

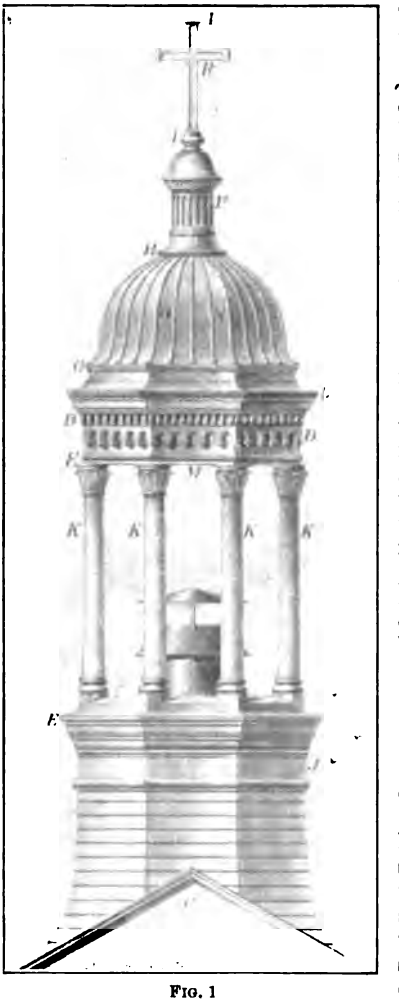

FIG. 1

The purpose of a cupola is usually to ornament or complete the architectural treatment of a building, but, on occasions, it also provides means of ventilation. The one with which we are treating fulfils the latter purpose by means of an Emerson ventilator, the construction of which will be fully described as we proceed.

The ¼-inch scale drawing was sufficient from which to make a preliminary study of the construction, but, if it is possible, a drawing to a larger scale should be secured from the architect, and it should be one showing all the details of the ornamentation and structural features of the cupola. Such a drawing,

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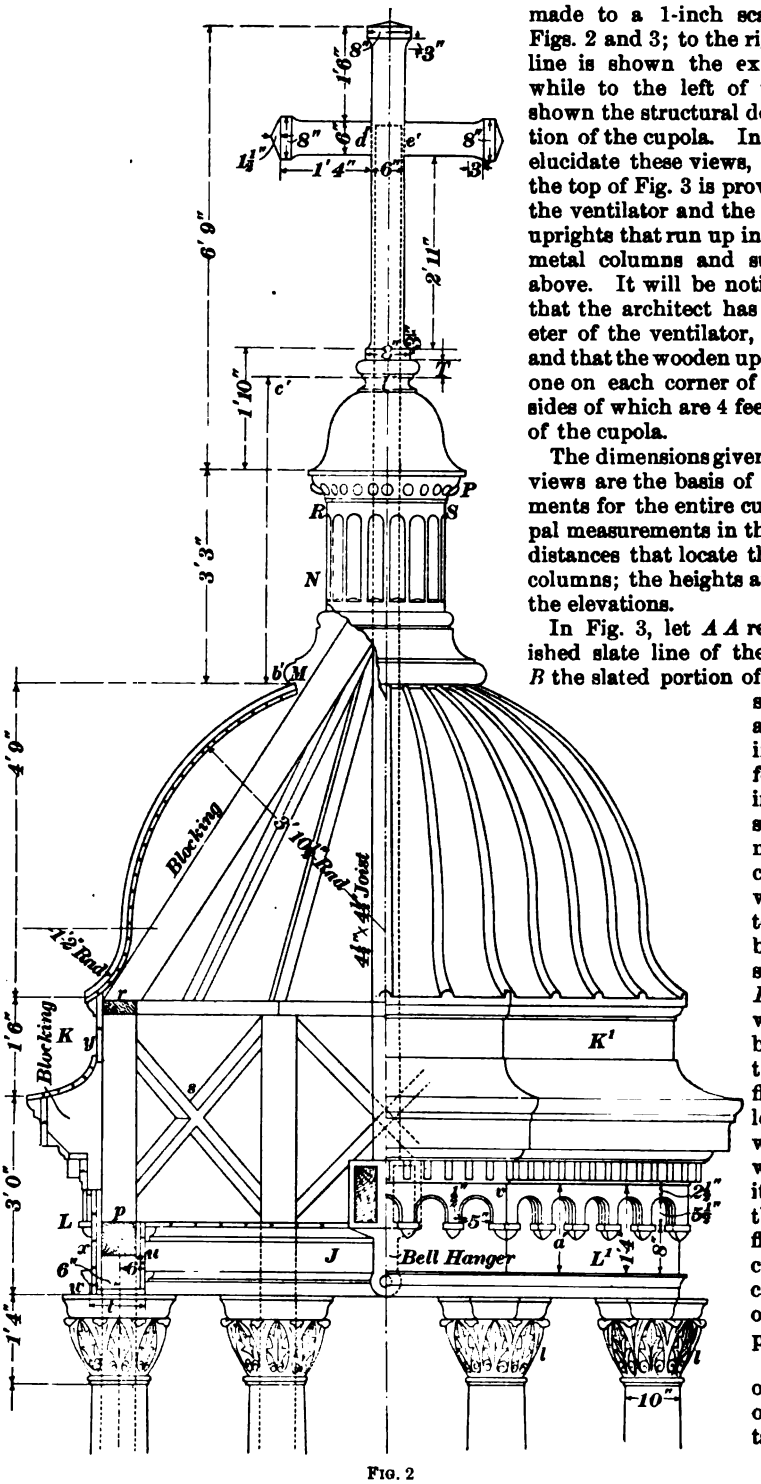

FIG. 2

made to a 1-inch scale, is shown in Figs. 2 and 3; to the right of the center line is shown the exterior elevation, while to the left of the same line is shown the structural details of that section of the cupola. In order to further elucidate these views, the half plan at the top of Fig. 3 is provided, and shows the ventilator and the 6″ × 6″ wooden uprights that run up inside of the sheet-metal columns and support the roof above. It will be noticed in this plan that the architect has given the diameter of the ventilator, 2 feet 9 inches, and that the wooden uprights are spaced one on each corner of the octagon, the sides of which are 4 feet from the center of the cupola.

The dimensions given in these several views are the basis of all our measurements for the entire cupola, the principal measurements in the plan being the distances that locate the centers of the columns; the heights are obtained from the elevations.

In Fig. 3, let *A A* represent the finished slate line of the main roof, and *B* the slated portion of the cupola base shown in section at *C*. Before laying out the details for the base molding *E*, shown in section at *F*, it is necessary to decide whether it will be advisable to first slate the base *B* and then set the base mold *E* over it, or whether it would be better to set the base mold first and slate the lower part afterwards. In the writer's opinion, it is better to set the base mold first, but, as circumstances alter cases, both methods will be explained.

Stretch a piece of drawing paper on the drafting table of such size

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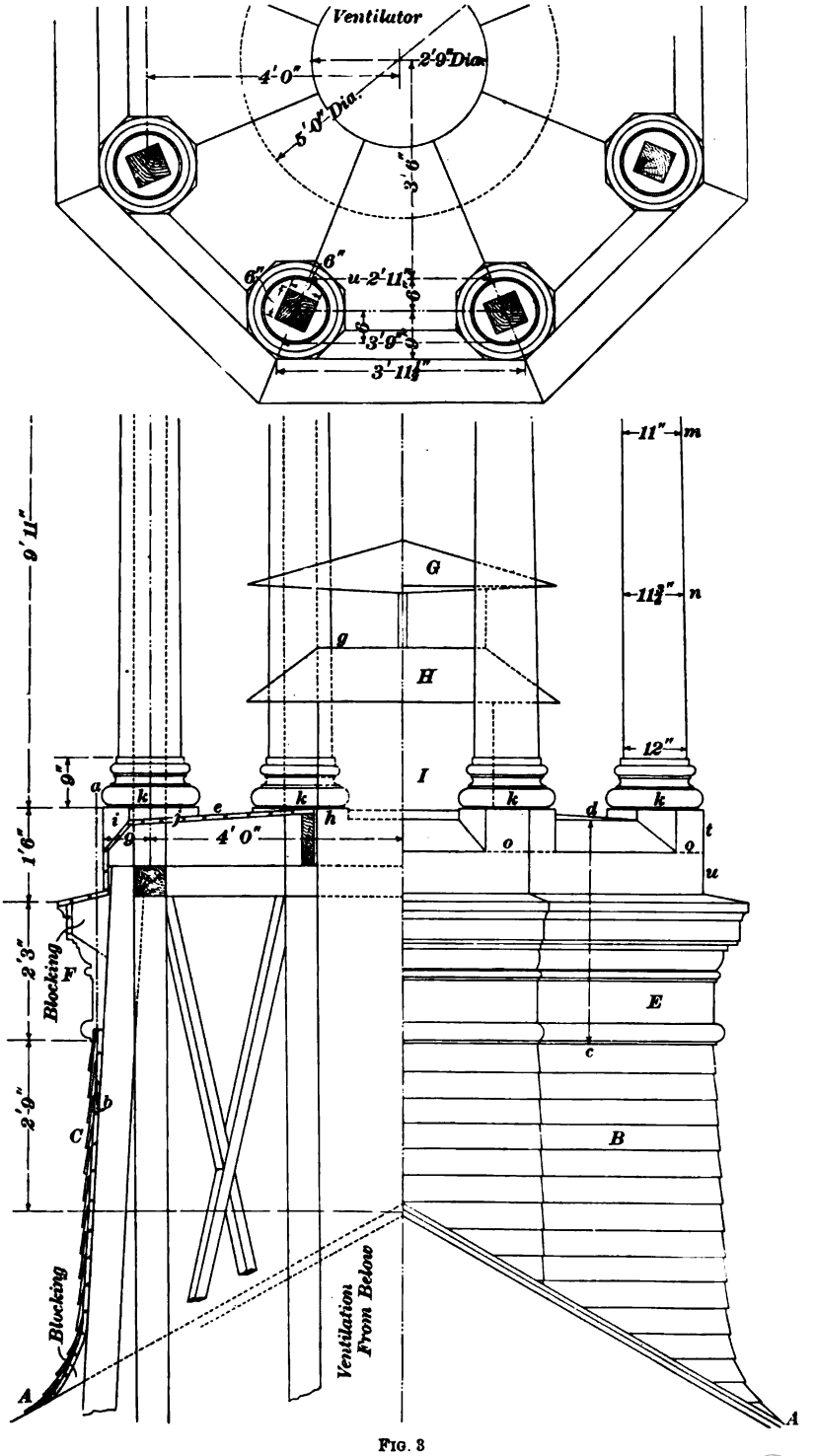

FIG. 3

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as will accommodate a full-sized drawing of the base of the cupola. With a scale, measure the vertical heights of all the members forming the base *F*, Fig. 3, marking them on a small slip of paper and transferring them full size to the vertical line *A B*, in Fig. 4. At right angles to *A B*, and through the points just transferred, draw horizontal dotted lines, as shown, on each of which measure off the proper projection, likewise obtained from the scale section *F*, Fig. 3, the measurements being taken from the line *a b*. Through the points thus obtained, trace the line *C D E*, which will be the full-sized profile for the base mold. The detail, as drawn, would indicate that the base mold would be first set, the lower slating *C*, Fig. 3, being put in place afterwards. For this reason, a groove 1 inch wide has been left behind the drip, as shown at *X*, Fig. 4, which allows three ¼-inch slates to pass in easily. If the base of the cupola were slated first, the lower part of the base mold *E* would be formed as shown at E^1, Fig. 5, and fastened in a manner that will be explained subsequently. It will be noticed that a lock is placed on top of the base mold at *C*, which is used to lock in the covering of the floor *e*, Fig. 3.

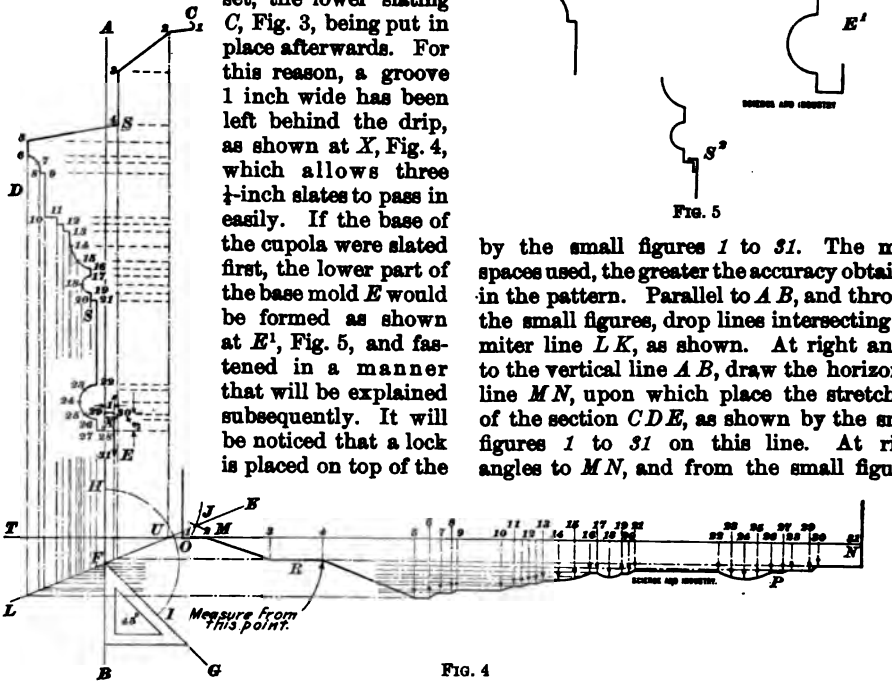

FIG. 4

The next step is to obtain the miter cut for the octagon angle of the base. To accomplish this, it is necessary to proceed as follows: Locate any point on the line *A B*, Fig. 4, as *F*, and with a 45° triangle placed against the vertical line *A B*, the point of the triangle being at *F*, as shown, draw the line *F G*; *H F G* will be the angle of the octagon. It will now be necessary to bisect the angle *H F G* so as to obtain the miter line in plan. In order to do this, set one leg of the compass at *F*, and, with any radius, describe the arc *H I*, cutting the lines of the angle *H F G* at *H* and *I*. With *H* and *I* as centers, and with a radius greater than one-half of *H I*, describe arcs intersecting each other at *J*. Draw a line from *F* to *J*, extending it either way, as shown by *K L*.

Having bisected the angle in this way, divide the profile *C D E* into spaces, as shown

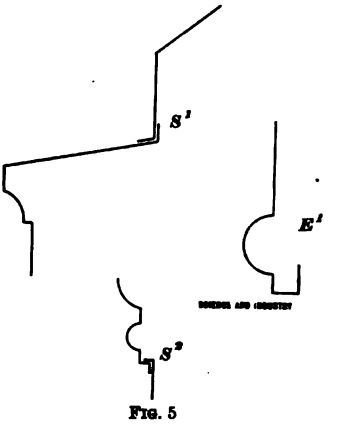

FIG. 5

by the small figures *1* to *31*. The more spaces used, the greater the accuracy obtained in the pattern. Parallel to *A B*, and through the small figures, drop lines intersecting the miter line *L K*, as shown. At right angles to the vertical line *A B*, draw the horizontal line *M N*, upon which place the stretchout of the section *C D E*, as shown by the small figures *1* to *31* on this line. At right angles to *M N*, and from the small figures, draw lines intersecting lines of similar numbers drawn at right angles to *A B* from the intersections on the miter line *L K*. A line traced through the points thus obtained, as shown by *O R P*, will be the miter cut for the octagon. Care should be taken to leave about a 2-inch space beyond the extreme points of the miter cut, as shown at *O*, which allows the pattern to be handled easily.

When the molding is of large size and the drawing board does not admit of obtaining the cut as just described, the horizontal line *M N* is laid out direct on a strip of iron, and

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the lines drawn at right angles to it; then the projections are obtained by measuring from any line, as $T\,U$, to the miter line $L\,K$, and transferring to the strip of metal. The base molding in this instance is of considerable height, as shown in the section F, Fig. 3, and seams must be provided, which are best located at S, S, Fig. 4. The joints or laps for these seams are shown at S^1 and S^2, Fig. 5; when made in this manner, the water is allowed to run over the seams, and not against them.

THE DUTY OF STEAM PUMPS

G. A. Goodenough

THE MEANING OF THE TERM "DUTY"—DUTY BASED ON COAL CONSUMPTION—DUTY BASED ON STEAM CONSUMPTION—DUTY BASED ON THE HEAT UNIT SUPPLIED TO PUMP

DUTY is a term used in estimating the performance of a pump or pumping engine. In a certain time, say an hour or a day, the pump raises a quantity of water through a certain height, and thus performs a definite amount of work. To do this work, the pump has received from the boilers a certain number of heat units, or a number of pounds of steam; or, if the boilers are included as a part of the system, the work has been accomplished at the expense of a quantity of coal. The pump is credited with the work it has performed in the stated time, and is charged with the number of heat units, pounds of steam, or pounds of coal it has used in doing the work. It is plain that the economy of the pump or pumping engine is measured by the ratio of the work performed to the steam consumed or the coal burned. Thus, if one pump does 50,000,000 foot-pounds of work with a coal consumption of 100 pounds, and another under the same conditions does 36,000,000 foot-pounds and consumes 60 pounds of coal, the latter is evidently the most economical, since the ratio of work to coal consumption is larger. This ratio between the work obtained from a pump and the coal, steam, or heat units put into it is the *duty* of the pump.

When the duty is based on the consumption of coal, it is customary to assume 100 pounds of coal as the fuel unit; that is, the duty is defined as the number of foot-pounds of work performed for each 100 pounds of coal burned. Expressed as a formula,

$$\text{duty} = \frac{\text{foot-pounds} \times 100}{\text{pounds of coal}}.$$

Suppose, for example, a pump raises 130,000 pounds of water a height of 60 feet, and the operation requires the combustion of 25 pounds of coal. The duty is

$$\frac{130{,}000 \times 60 \times 100}{25} = 31{,}200{,}000 \text{ foot-pounds}$$

per 100 pounds of coal.

The duty based on the coal consumption is of practical value, as it gives an idea of the coal required by a pump of a given type for the performance of a stated quantity of work. It is clear, however, that if a comparison of the merits of two pumps is to be made, the coal must be of the same quality in each case. Further, the boilers supplying steam to the pumps should be of the same type, or at least have the same evaporative capacity. This is a point of great importance. One hundred pounds of good bituminous or anthracite coal may, under favorable conditions, evaporate 1,000 to 1,100 pounds of water; that is, furnish that number of pounds of steam to the pump. In many cases, however, the 100 pounds of coal, if of inferior quality and burned under a poor boiler, will not furnish the pump more than 450 to 600 pounds of steam. Under such conditions, the duty of the pump would not be a fair indication of its efficiency, and would not serve as a satisfactory basis for comparing it with other pumps.

To avoid this difficulty, it has been the custom of some pump makers to specify that the coal consumption shall be estimated on the supposition that a pound of coal evaporates 10 pounds of water, or, in other words, furnishes 10 pounds of steam to the pump. To make this clear, suppose that in a duty trial 32,000 pounds of steam were used by the pump; the duty of the pump would be calculated on the assumption that the coal consumption was $32{,}000 \div 10 = 3{,}200$ pounds, though 5,000 pounds might actually have been used. If 1 pound of coal is assumed to furnish 10 pounds of steam, 100 pounds of coal will furnish 1,000 pounds

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of steam; hence, the duty may be defined as the number of foot-pounds of work done by the pump per 1,000 pounds of dry steam supplied to it. This definition may be expressed by formula as follows:

$$\text{Duty} = \frac{\text{foot-pounds} \times 1{,}000}{\text{pounds of steam}}.$$

In a duty trial, a pumping engine used 8,100 pounds of steam, and lifted 7,920,000 pounds of water a height of 126 feet. The work done by the pump was $7{,}920{,}000 \times 126 = 997{,}920{,}000$ foot-pounds. The duty per 1,000 pounds of steam was

$$\frac{997{,}920{,}000 \times 1{,}000}{8{,}100} = 123{,}200{,}000 \text{ foot-pounds.}$$

In this trial, the boiler used 1,100 pounds of coal; hence, the duty per 100 pounds of coal was

$$\frac{997{,}920{,}000 \times 100}{1{,}100} = 90{,}720{,}000 \text{ foot-pounds.}$$

The basis of 1,000 pounds of dry steam is more scientific and better adapted for duty trials than that of 100 pounds of coal, but it is open, nevertheless, to objections. Not only is it difficult to determine the exact weight of dry steam entering the pump, but also 1,000 pounds of steam at 160 pounds pressure will do more work in the cylinder than 1,000 pounds of steam at 60 pounds pressure. If scientific accuracy is sought, the pressure of the steam should be specified in addition to the weight.

On account of the objections to the existing units, The American Society of Mechanical Engineers, in 1891, decided to adopt a new basis for the estimation of duty. Whether the furnace consumes 100 or 200 pounds of coal, whether the steam is at 60 or 160 pounds pressure, wet or dry, the steam cylinders of the pump or pumping engine receive, in a given time, a definite number of British thermal units. We have seen that if each of two pumps is allowed 100 pounds of coal to do a certain amount of work, one of the pumps may be at disadvantage on account of the poor quality of the coal or the inefficiency of the boiler. If each is allowed 1,000 pounds of dry steam, there may be an inequality because of a difference in the steam pressure in the two cases. If, however, each pump is furnished with an equal number of heat units, each has exactly the same stock in trade, and the merit of each pump can be gauged by the use it makes of the heat units furnished it; that is, by the ratio of work performed to heat units supplied.

If a pound of water has a temperature of 212°, it requires 966.1 B. T. U. to change it to steam at atmospheric pressure. If the water has originally a lower temperature, or is converted into steam at higher pressure, more B. T. U. are required to accomplish the change. Roughly speaking, if the temperature of the feed and pressure of the steam are not given, about 1,000 to 1,100 B. T. U. are equivalent to a pound of steam. Therefore, 1,000 pounds of steam are equivalent to about $1{,}000 \times 1{,}000 = 1{,}000{,}000$ B. T. U.

Looking at the question in another light, a pound of good coal when burned produces about 13,500 to 14,000 B. T. U. by the combustion. A boiler of fairly good efficiency will utilize perhaps 10,000 of these 13,500 B. T. U., the rest being lost by radiation, in the production of chimney draft, and in other ways. From 100 pounds of coal, the boiler is able to extract $100 \times 10{,}000 = 1{,}000{,}000$ B. T. U., which are eventually given up to the pump. It thus appears that 100 pounds of coal and 1,000 pounds of steam are each approximately equivalent to 100,000 B. T. U.; for this reason, the committee of The American Society of Mechanical Engineers recommended that the new basis for estimating duty should be 1,000,000 B. T. U.

Using the heat-unit basis, the formula for duty becomes:

$$\text{Duty} = \frac{\text{foot-pounds} \times 1{,}000{,}000}{\text{B. T. U. supplied to pump}}.$$

The heat-unit basis is now very extensively used in this country, and is recommended in preference to the others.

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OLD-TIME CONSTRUCTION

F. A. Kaiser

A FEW days ago the estate of Judge Wm. V. B. Croskey, of Steubenville, Ohio, tore down a house said to be the first brick house built west of the Ohio River, and probably west of Pittsburg. Thinking that both the history and the constructive features of this building might be of interest to your subscribers, I send below a brief description.

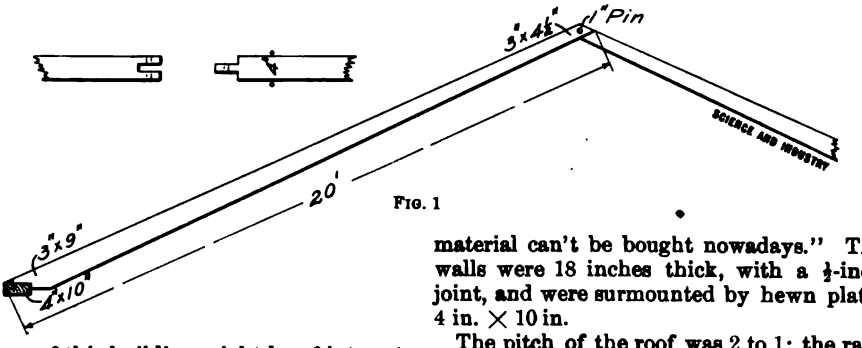

FIG. 1

Brice Viers, his wife, and mother, about 1760, were among the first settlers, on the spot where Steubenville now stands, on the west bank of the Ohio River, at that time the "far west." He established there the first tannery, preparing the skins of both wild and domestic animals (with occasionally a redskin), and soon became, for those days, a man of great wealth. In 1775, one year before the Declaration of Independence, he determined to build a brick house for the protection of his wife and mother. The house built at that time was one and one-half stories high, containing two rooms and a sleeping loft.

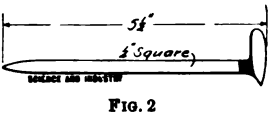

FIG. 2

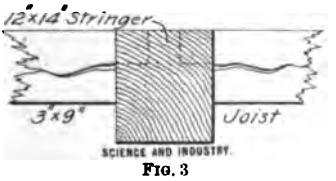

FIG. 3

In 1806, a two-story addition was built, but the original structure was undisturbed and was copied so closely in the addition that one description will apply equally well to both.

The bricks, 9½ in. × 3 in. × 4½ in., which were burned on the spot, are still in perfect condition. They have a bright-red color, and the mortar adheres to them so firmly that the masons now at work echo the usual false and pessimistic opinion that "such material can't be bought nowadays." The walls were 18 inches thick, with a ½-inch joint, and were surmounted by hewn plates 4 in. × 10 in.

The pitch of the roof was 2 to 1; the rafters were hewn from oak and were tapered, being 3 in. × 9 in. at the lower end, and 3 in. × 4½ in. at the top, where they met in a hinge joint, as shown in Fig. 1, and were secured by an oak pin. At the bottom, the rafters rested on the cap, as shown, and were fastened with hand-made spikes, shown in Fig. 2. The roof was covered with split-oak lath and originally with split shingles, though only a few of the latter, which were covered with newer ones, were found.

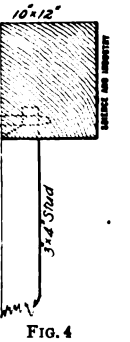

FIG. 4

The house was about 20 feet wide, but the builders seemed to think this too great a span for their oak joists. Accordingly, a 12″ × 14″ hewn timber, about 30 feet long, was run down the middle of the house, the ends resting on the foundation walls, and

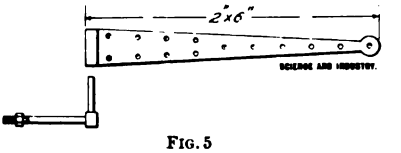

FIG. 5

in this were framed 3″ × 9″ joists, as in Fig. 3. The joists were nearly all badly split, so that their effective depth was reduced to less than 4 inches. The floor

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was of tongued-and-grooved oak boards, 1 inch thick and from 3 to 6 inches wide.

Along the side of the stair wall, in the second story, there ran a 10″ × 12″ oak timber. In this, 3″ × 4″ studs were framed, 2 feet apart, as in Fig. 4. These studs were covered with split-oak lath, about 1½ in. × ¼ in., in cross-section, 4 feet long, and very irregular. A coarse plaster sand surface formed the finish. Another partition consisted of studs to which oaken boards were nailed on each side, the whole being covered with linen and many layers of paper.

FIG. 6

The inside finish was of oak and walnut, some of it handsomely carved. The doors were paneled, and the outside one reenforced by heavy oak battens secured with long nails clinched on the inside. The hinges, which are shown in Fig. 5, were of iron, 2½ feet long and firmly nailed and bolted.

The stairway was 5 feet wide, and so firmly pinned together that it had to be entirely demolished in being removed. The treads were 12 inches wide and the risers were 8 inches high. A section of the walnut hand rail is shown in Fig. 6.

FIG. 7

Under the eaves was suspended a wooden gutter of the section shown in Fig. 7. This gutter was made of pitch pine and was badly split and decayed. Most of the timber in both buildings was in very good condition, the only exception being the ends of the heavy stringer, Fig. 3, which were badly rotted where they rested on the foundation walls.

A peculiar bit of outside finish, shown in Fig. 8, illustrates the extreme care used in all the work. This was made of white pine and was placed along the eaves. All the ornaments appear to have been carved with a chisel, though many of the smaller pieces

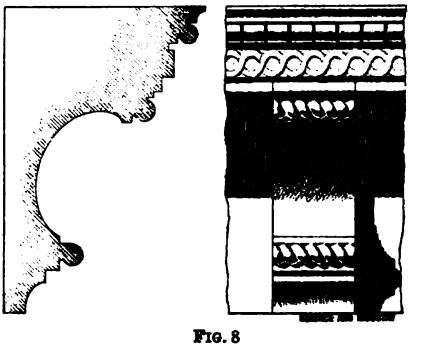
FIG. 8

are fastened on with nails. There is about 60 feet of this finish, and all is in fairly good condition.

To Brice Viers were born in this house sixteen children, all of whom reached maturity. One of these children, Bazaleel Viers, the father of the present owner, was born and died in the same room. A cousin of his, Edward Viers, was the man that first employed James A. Garfield as a mule driver on an Ohio canal.

LONG-DISTANCE TELEGRAPHY

THE record for long-distance practical telegraphing was broken by the Associated Press, on April 25th, 1899. A continuous circuit of 6,000 miles, reaching from New York City to the Pacific Coast, and from Chicago to New Orleans, touching Philadelphia, Pittsburg, Cincinnati, Atlanta, Memphis, St. Louis, Kansas City, Omaha, Denver, San Francisco, and all the larger intermediate points south and west, was successfully worked for several hours.

There were forty-one operators copying from a sender in New York, with newspapers being served directly from this one circuit in thirty-eight of the leading cities of the United States.

Longer circuits have been worked for short periods, but, as far as known, this record has never been equaled, considering the number of operators copying, the number of newspapers served, and the territory covered by the circuit.

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USEFUL IDEAS

THREE USEFUL ELECTRICAL IDEAS

Electrician

A METHOD of tapping cord to obtain a temporary electric current is shown in Fig. 1; b and b' are ordinary pins clamped between

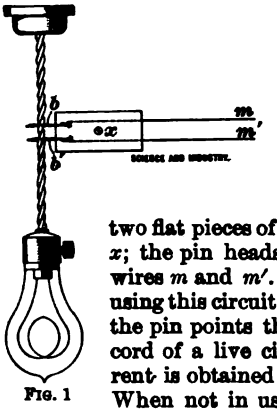

FIG. 1

two flat pieces of wood by a screw x; the pin heads are soldered to wires m and m'. The method of using this circuit tapper is to push the pin points through the lamp cord of a live circuit, when current is obtained from m and m'. When not in use, the pin points are inserted in a common cork, to prevent them from becoming bent.

Fig. 2 is a modification of the same idea; pins e and e' are soldered to the terminals of an incandescent lamp and inserted in the lamp cord when an extra light is required for temporary use.

FIG. 2

Fig 3 shows a simple arrangement for measuring a current approximately; g is a piece of wood, f is a piece of tin-foil or tinsel paper. Connect the wires s and s' in circuit with four incandescent lamps, of 16 candlepower each, connected in parallel. Each of these lamps requires about $\frac{1}{2}$ ampere on a 110-volt circuit, so that 2 amperes flow through the foil f. Now, while the current is flowing,

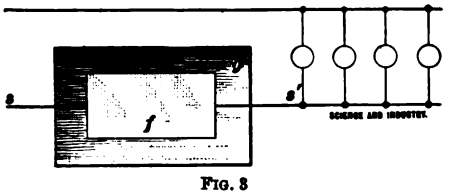

FIG. 3

take a knife and reduce the width of f until the tin-foil fuses. This will be the width of tin-foil that will carry 2 amperes, and from this it is easy to measure the strength of any current by using a new piece of foil in the place of f and reducing its width until it fuses, when the strength of the current is easily estimated. While this method is not as accurate as a good

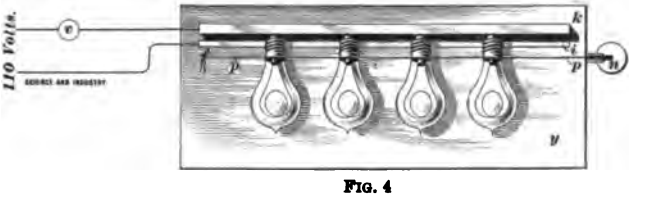

FIG. 4

ammeter, it is a good and cheap substitute for one. Figs. 4 and 5 show an incandescent-lamp rheostat; y is a dry board; k is a bar of metal, $\frac{3}{4}$ in. $\times \frac{1}{4}$ in., fastened to the board; i is a metal ribbon fastened about $\frac{1}{4}$ inch from k. The incandescent lamps are placed on the metal ribbon i and moved up against k so as to complete the circuit through the lamps; p is a string fastened at one end to the board, and, passing over the lamps, holds them in position; n is a weight tied to the string to keep it taut; v is the apparatus to be connected in the circuit. The current is varied by varying the number of lamps in circuit.

FIREPROOF FLOOR CONSTRUCTION

Emil G. Perrot, Philadelphia, Pa.

THINKING that the following description of securing the finishing floor in a building to the steel floorbeams would be of interest to some of your readers, I send

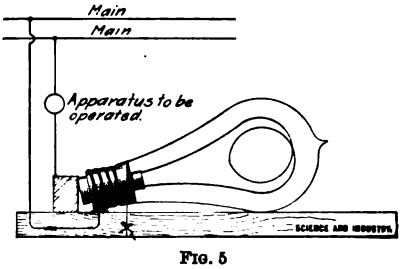

FIG. 5

the same for publication, should you consider it worthy of a place.

With the almost universal use of steel in

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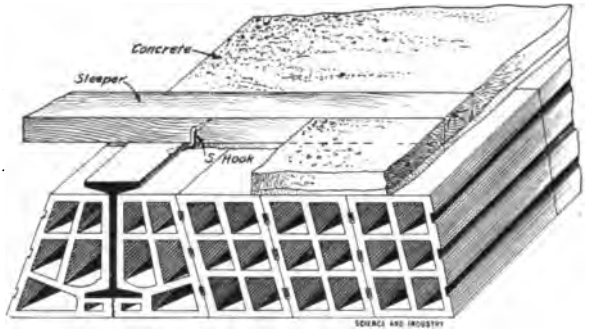
the construction of important buildings, especially in fireproof floor construction, it becomes necessary to devise adequate means of securing the top flooring of wood in a permanent way to the floor construction. There are several different methods by which this has been done. Some of these are of a very indifferent nature, and should not be used. Having given the subject careful attention, and thinking that my observations might be of service to those that are looking for a substantial method of securing the top flooring of the building to the terra-cotta and steel construction, I offer the method shown in the accompanying sketch. It has been used very successfully in several important buildings, and has



demonstrated its superiority over the method of embedding trapezoid-shaped sleepers in the concrete. The writer once visited a very modern building that was intended to be fireproof, in which the finishing flooring was nailed to sleepers embedded in the concrete as mentioned above. Parts of the floor, however, were badly sprung and entirely out of place, allowing an open space between the floor and the concrete, which is, of course, bad in fireproof construction. The reason for this may be that the sleepers, shrinking in the grooves formed in the concrete, offered considerable play for the flooring, or possibly the concrete was very indifferently and loosely rammed between the sleepers, thereby forming no key. The method herein recommended makes use of the steel beams for securing the sleepers, no dependence being placed on the concrete filling to hold the sleepers in position. As will be noticed in the sketch, small iron S hooks, as they are styled, are made of, say, $\frac{5}{16}$-inch square or round iron, pointed on one end, and having the stems turned at right angles to each other in such a manner that they can be driven into the sleeper and at the same time form a hook under the top flange of the beam. The sleepers are placed the usual distance apart, in order that the floor may be securely nailed in position. By this combination it is impossible for top flooring to become loose or spring up from its original position.

A GOOD SCHEME, BUT NOT PERFECT

Ed. I. Noble, Scranton, Pa.

I WAS much struck with the novel blueprint frame as described by E. Percy Lea, of Mexico City, in the columns of the April issue. At the time of reading this, I had considerable blueprinting to do, and not possessing a frame of sufficient size, I concluded to try the device that he describes. It worked very successfully, and there was but one objection to it, which was that, though it did not interfere with its practical usefulness, it did not produce a blueprint of good appearance. When the bent surface of the cardboard with the tracing and blueprint upon it was exposed to the sunlight, there was a certain portion of the curve in high light, while other portions were in the shade. This produced unequal exposure, and, consequently, on washing the blueprint I found that the portion subjected to high light was of a good deep blue, while that in the shade was somewhat whitish in appearance. The entire print was, however, perfectly legible, and I heartily thank Mr. Lea for the suggestion.

A RULING AND ERASING SHIELD

D. J. Kelsey, New Haven, Conn.

LIKE all other draftsmen, I have had troubles of my own where it became necessary to erase part of a drawing, it being very difficult to erase with a rubber without disturbing lines adjacent to the one to be erased. I then tried a metallic erasing shield, which, though it worked very well indeed, was still objectionable on account of the difficulty of placing it correctly over the line to be erased. The idea then struck me that if it could be made of transparent material, it would be just the thing for a busy man. After some experiments, I determined that transparent celluoid would be most satisfactory. Constant use proved its value. About this time it occurred to me to form the

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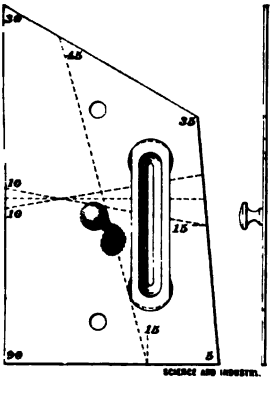
erasing shield in the most useful article in a draftsman's outfit, viz., the triangle. After considerable thought, I made a triangle as shown in the accompanying illustration. By using the edges, which make angles as marked in the corners, either alone or in conjunction with lines ruled on the under surface, I can obtain every fifth degree of a right angle, with the exception of 25° and 65°. This makes it a very handy instrument for the draftsman and anybody else that has occasion to make mechanical, architectural, or other drawings. It is handy for such work as drawing square and hexagonal boltheads, screw threads, coil springs, teeth of worms and racks, friction cones, gibs, tapers on hubs and bosses, die blocks, key ends, etc. Having had numerous calls from my friends, after making a number by hand, I finally decided to make them by machinery, and am thus enabled to furnish one to any one that has use for this instrument, at the low price of 35 cents. I am also making them with a removable groove at a price of 45 cents, thus allowing a new groove, at a price of 5 cents, to be inserted when the old one is worn out, which in ordinary work will be in about three years. The 90° side of this device is about 5 inches long.

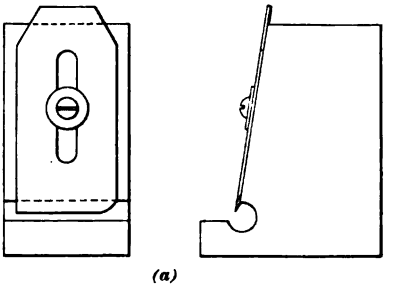


A NOVEL DOWEL CUTTER

Elmer H. Karp, Chicago, Ill.

I HERE submit to the readers of SCIENCE AND INDUSTRY a method of making a cheap dowel cutter. Take a piece of hard wood about 5½ in. × 3 in. × 3 in., and bore a hole in it the size of the dowel desired, or a little larger, and cut it to the shape shown at (*a*). After the block is shaped, take an old plane iron and round off one corner, sharpening it and fastening to it the block by means of a screw and washer, as shown. The hole may be made somewhat larger at the right-hand side, so as to admit the rough piece of wood that is to be worked. Secure another piece of wood and cut a square hole in it slightly larger than the dowel. Fasten this piece to the face plate and put it in the lathe as shown at (*b*). Care should be taken to have the hole exactly in the center.

The pieces of wood from which the dowels are to be cut are square and about 1 foot long, the dimensions of the section being the same as that of the square hole cut in the block secured to the face plate. Cut off the corners at one end of the piece and insert the square end in the hole in the wood on the face plate, putting the other end in the dowel cutter already made. Holding the cutter in your hand in line with the lathe centers, start the lathe and move the cutter toward the face plate. The



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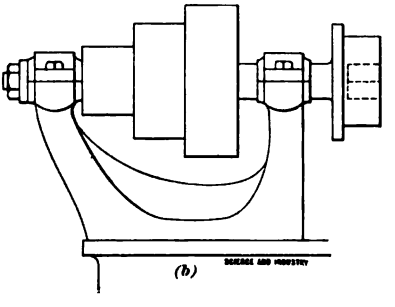

(*b*)

dowel thus made will be found to be all that is desired, and when you have this apparatus once rigged up, dowels can be turned out rapidly and cheaply.

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EDITORIAL COMMENT

ILLUSTRATED TIME BOOK

THAT very enterprising firm, Hamilton Carhartt & Co., Detroit, Mich., the celebrated manufacturers of union-made clothing, are giving with their advertising literature a handsome time book. They will be pleased to send this time book free to any of our readers sending their name and address.

THE CROSS OIL FILTER

THE new power plant of the electric street-railway company of the City of Mexico, which is the finest in that country, has been installed entirely with American machinery, and the oiling system in use is that of the Burt Manufacturing Company, of Akron, Ohio, manufacturers of the celebrated Cross oil filter.

THE ERICSSON SERIES OF TELEPHONE INFORMATION

THE Ericsson Telephone Company, 296 Broadway, New York, have recently brought out Part 3 of "The Ericsson Series." It contains some information on induction coils and on the history and use of telephones in Norway and Austria that should prove very interesting to electricians and telephone people. Any one sending their name and address to the Ericsson Telephone Company will receive a copy free of charge by return mail.

THE STANDARD TOOL COMPANY

THE latest catalogue of The Standard Tool Company, Cleveland, Ohio, manufacturers of twist drills, reamers, sockets, drill chucks, etc., has been received. This catalogue represents a new departure in that all descriptive matter is printed in three languages, viz., English, French, and German. Evidently, this company does not intend to follow the only too common policy of sending catalogues printed in the English language to foreign countries—a policy that can scarcely be said to be especially adapted to the securing of foreign trade.

MAJOR'S CEMENT

IT IS hardly necessary to say anything about Major's cement—everybody knows what it is and how it sticks; but it is not, perhaps, so generally known that in addition to the regular article, there is also Major's rubber cement and Major's leather cement. We are informed by Mr. Major that one of the reasons for the success of his cement is that he uses the best materials known, regardless of cost; in fact, he states that one of the elements of his cement costs $3.75 per pound and another $2.65 per gallon. Hence the moral, "Insist on having Major's; don't accept any off-hand advice from the druggist," seems to be particularly applicable in this instance.

THE ERWIN STEAM RAM

WE HAVE received the catalogue of the Erwin steam rams from the Penberthy Injector Company, Detroit, Mich. These rams are well adapted for elevating water for apartment buildings, residences, summer resorts, hotels, factories, farm use, stock yards, railroad tanks, mining and irrigation purposes, etc. They are built with capacities from 400 to 8,000 gallons per hour, forcing water to a height of 60 feet, and are suitable for tubular or other wells, and for raising water from cisterns, lakes, or streams. The small dimensions of this steam ram, and the amount of work it will do, coupled with its light weight and durability, make it available for many places and purposes. Judging by the large number of testimonials from users, they have proved very satisfactory wherever used. The catalogue will be sent free on application to the builders.

WORCESTER POLYTECHNIC INSTITUTE

THE catalogue of the Worcester Polytechnic Institute contains much information of interest and value to all that are contemplating entering one of the engineering professions. The residences and occupations of all living graduates, nearly eight hundred in number, are shown, and it is interesting to note that they are scattered over the civilized world, engaged, almost without exception, in mechanical, civil, electrical, or chemical engineering, for which they were trained at the institute. Many of them fill places of great importance and responsibility. The remarkable growth in all engineering and industrial operations that has taken place during the past few years has greatly increased the demand for young men educated in technical schools. The Worcester school was one of the earliest of its kind established in this or any other country. It has constantly added to its

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equipment and enlarged its facilities so as to be able to meet the more exacting requirements of the present time. As a result, the demand for its graduates is now, and has been for some time, much greater than the supply, many members of the class to be graduated in June having already received appointments to desirable positions.

THE CORNISH PIANOS AND ORGANS

Owing to sharp competition in every line of business, it is the tendency of manufacturers today to reduce expenses wherever possible, in order to be able to meet competition and still make a fair profit on the capital invested. There are two ways of reducing expenses, which may concisely be called the right way and the wrong way. Of these, the latter, which usually takes the form of reducing the wages of the employes, is the one more commonly adopted. With it naturally comes a train of evils: dissatisfied workmen, slighted workmanship, a lowering of the quality of goods with consequent dissatisfaction of the buyers, and, sooner or later, failure. The right way of reducing expenses is to cut off all unnecessary expenses. Very few people indeed, outside of those engaged in manufacturing, know what an enormous percentage of the actual cost of goods the selling expenses constitute. Expensive warerooms, high-salaried salesmen, storage charges, insurance premiums, etc. often make the price that has to be charged, in order to make a fair profit, double the original cost of producing the article. Then, a reduction of selling expenses, one that will not decrease sales, will allow either one of two things to be done: *first*, it will allow a superior article to be produced for the same selling price; or, *second*, it will allow a grade equal to the former grade to be sold for less money.

The right way here enumerated has been adopted by Cornish & Co., manufacturers of American pianos and organs. They are located at Washington, N. J., alongside the tracks of the Delaware, Lackawanna, and Western Railroad. More than 25 years ago they adopted the "from-factory-to-family" plan, selling and shipping direct from the factory to the consumer, thus eliminating the expenses of the middleman and reducing the selling expenses to a minimum. When they first commenced business, they sold pianos and organs at the rate of $5 a month to schools, churches, etc. Owing to the adoption of the mail-order plan, their business grew so rapidly that their average sales are now 1,000 instruments a month. The only branch office this concern has is located in London, England.

Cornish & Co. warrant every instrument for 25 years, allowing a buyer to try his instrument for 30 days or for a year, as preferred. If unsatisfactory, the buyer himself being the judge, he may return it at the expense of the company, when they offer to return any money that has been paid, with interest at 6 per cent. This guarantee shows the confidence of the company in the excellence of their products.

In a profusely illustrated catalogue, all the fifty different pianos and organs are described at length. This catalogue will be sent, free of charge, by the makers to any one applying for it. The prices of the organs range from $25 to $125; the pianos, from $155 to $295.

BOOK NOTICES

The Elements of Alternating Currents. By W. S. Franklin and R. B. Williamson. The Macmillan Company, New York. 212 pages. Price, $1.75.

"Nature," the leading English scientific journal, has a brief review of this book in its issue of April 19, 1900, from which we make the following extract:

"In this book will be found a very fair résumé of the theory and practice of alternate-current working, and of the modern developments associated with the use of polyphase currents and the induction motor. * * * The comments upon the practical aspect of each question taken up are of great value, especially to readers in this country, where experience with polyphase currents is limited to some half dozen installations of but few months standing. * * * Much information is to be found in this book in small compass, and it will prove of value to engineers engaged in alternate-current practice."

Messrs. Franklin and Williamson have treated the subject with highly commendable conciseness, and at every point have kept in mind the practical engineering applications. The value of the book is very much enhanced by an abundance of most excellent graphical constructions. Mr. R. B. Williamson, one of the authors of the book, is professor of electrical engineering in The International Correspondence Schools, of Scranton, Pa.

Our New Prosperity. By Ray Stannard Baker. Published by Doubleday & McClure Company, New York. Price, cloth, $1.25.

A witty Western writer, summing up the

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marvels of growth, expansion, and prosperity of the year 1899 in the United States, made this his telling climax: "And every barn in Kansas and Nebraska has had a new coat of paint." Such is the opening sentence of a book that every patriotic American that glories in the progress and prosperity of his country ought to have and read; it will prove a revelation to him. The book is freely illustrated with diagrammatic pictures that serve to bring out more forcibly the statistical facts. We understand that the figures given are thoroughly reliable, Mr. Baker's investigations having been checked by high authorities. The book is well written and is very entertaining reading.

THE TECHNIC OF MECHANICAL DRAWING. A practical guide to neat, correct, and legible drawing. By Charles W. Reinhardt. The Engineering News Publishing Company, New York. Price, $1.00.

This is a book 8 in. × 11 in., in which the writer has endeavored to give the busy draftsman common-sense directions on the execution of a good, legible, and neat drawing. Since the book is intended for people conversant with the principles of mechanical drawing, none of the elementary exercises are given. The book is divided into eight chapters: general instructions, outlining, outline shading, section lining, curved-surface shading, shading of inclined surfaces, map drawing, and character and finish. The text, which is illustrated by numerous well-chosen figures, is followed by 10 plates giving examples of properly executed drawings. It is apparent that the writer has had considerable practical experience in the production of neat and legible drawings, for without this experience in commercial work, it would have been impossible to have produced a book so full of valuable information from cover to cover as this one. It should prove of value to any draftsman, and be a valuable aid to any beginner.

THE GAS ENGINE HANDBOOK. A manual of useful information for the designer and engineer. By E. W. Roberts, M. E. Price, in flexible cloth, $1.00; in leather, $1.25. The Gas Engine Publishing Co., Cincinnati, Ohio.

The great interest that the rapid development of the gas engine and its application has aroused among engineers and power users has created a demand for practical information regarding the construction and operation of recent American types of this motor. To meet this demand, the little book before us was prepared. It furnishes, in a small space, just the kind of information that the buyer and user of a gas engine wants and finds most difficult to obtain. No attempt is made to advertise any make of engine; consequently, the book is entirely void of material with the earmarks of engine builders' catalogues that helps to fill the pages of many so-called books for engineers, but adds so little to their practical value.

In addition to the practical information for the use of gas-engine buyers and runners, several chapters are devoted to rules and formulas for the design of details. Most of these rules and formulas are empirical; being based on the practice of successful builders, however, they will serve a useful purpose for those designers that have nothing better on which to base their work than a theoretical knowledge of the subject of the gas engine, combined with experience in the design of other types of machinery.

COMPOUND ENGINES. A series of lectures by F. R. Low; reprinted from the columns of "Power." The Power Publishing Company, New York. Flexible, cloth; price, 50 cents.

This is a neat pamphlet of 52 pages, in which the theory of compound engines is explained in such a manner that it can readily be understood by the practical steam engineer. The only fault we can find with it is that, in the effort to make it appeal to practical men, the author frequently uses the word "power" as synonymous with "work." Thus, on page 3, power is wrongly defined as "force exerted through space." In our opinion, such looseness in the use of technical terms, while perhaps pardonable on account of the good intention, neither adds to the value of a technical publication nor contributes to a better understanding of the subject.

In order to properly present the subject, it is introduced by a brief but comprehensive outline of the laws underlying the expansion and expansive working of steam, which is followed by an explanation of the gain in economy due to compounding. A discussion of the ratio of expansion suitable for maximum economy is presented next. The combining of diagrams from compound engines is explained in the succeeding chapter in a very clear manner, and is followed by a discussion of receivers for tandem and cross-compound engines. The pamphlet deals entirely with the theory of compound engines, no attempt having been made to discuss their construction. It should prove of value to the student as well as to the running steam engineer.

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ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*
2. *Only questions of general interest to our readers will be answered.*
3. *No questions will be answered by mail.*
4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*
5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*
6. *Reference to inquiries previously answered should give date of issue and number of question.*
7. *Questions cannot be answered in the issue of the month immediately following their receipt.*
8. *Any book not out of print and for sale by regular dealers may be ordered through the magazine.*
9. *We will not undertake to calculate windings of dynamos and motors, as this involves considerable work and is seldom justified.*

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(311) (*a*) Give a simple method of testing oil for acids, and also for its lubricating qualities. (*b*) Is there a simple method of testing bituminous coal? (*c*) Can you furnish a recipe for case-hardening that will give colors such as appear on the breech blocks of rifles? (*d*) Give a recipe for gluing leather on smooth iron faces, tapered as in friction clutches.
C. M. G., St. Hyacinthe, Can.

ANS.—(*a*) To determine acidity, pour a few drops of the oil into shallow depressions in a brass or copper plate and heat it to 120° or 140° F. for a few hours. If the oil contains acid, a green luster appears, which is especially perceptible on the edge of the oil. By heating the oil for a longer time the tendency of the oil towards acidity may be recognized by the degree of the green coloration, which becomes constantly more pronounced. The value of lubricating oil is in inverse ratio to its tendency to thicken or even become solid at low temperatures, and it is rated accordingly. Expose the samples of oil in test tubes in an ice chest; the sample that thickens the least is the best lubricant. (*b*) You do not state for what purposes you want to test the coal, whether for a chemical analysis or for its heating value, etc. We would recommend Stillman's "Engineering Chemistry," price $4.50, in which you will find all the necessary tests of coal and oil thoroughly described. This book may be purchased from The Technical Supply Co., Scranton, Pa. (*c*) Put the articles in an iron box, packing them in bone dust mixed with scraps of old leather, such as old belting, shoes, etc. Close the box and make all joints air-tight with fireclay; then heat the box and keep it at a red heat for from 3 to 10 hours, according to the depth to which the articles are to be case-hardened. Next, dump all the contents of the box in clear water. The articles should be highly polished, and should be perfectly free from grease before they are packed in the box. (*d*) Apply a coat of lead paint, either white or red, to the iron. When dry, cover the coat of paint with a cement prepared as follows: Soak glue of the best quality in cold water until soft, then dissolve it in vinegar at a moderate heat; add one-third of its volume of white oil of turpentine, and after thoroughly mixing, apply the cement while warm with a brush, and press the leather on it.

***

(312) Please explain the best way to telegraph and telephone over the same line wire, and give a diagram of connections. A. S., Chester, Ill.

ANS.—This question is too long to answer here, but a full description of one method, with diagrams, is given in an article elsewhere in this issue.

***

(313) Explain how to transfer designs from paper to quicksilver, and the mode of acid-proofing.
W. A. B., Melrose Park, Ill.

ANS.—You will find this question answered in Answers to Inquiries, No. 87, of the March, 1900, issue.

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(314) Will you inform me where I can purchase a device for cooling sterilised water? I have seen a circular describing such a device, but it has been mislaid. The cooler is made of nickelplated brass, and the ice is put in the box, but does not come in contact with the water. There is no coil, as in most coolers. W. P., Lynchburg, Va.

ANS.—We do not know who makes such a device. Perhaps some of our readers may be able to tell us.

***

(315) (*a*) Does not the pressure in the receiver of a compound engine act as back pressure on the high-pressure cylinder? That is, if the M. E. P. in the high-pressure cylinder is 100 lb., and the pressure in the low-pressure cylinder at cut-off is 20 lb., would not the 20 lb. act as back pressure on the high-pressure cylinder? (*b*) Why do duplex pumps, such as the "Snow," have one direct and one indirect rocker-arm to operate the valves? Is there any special rule for setting the valves of such pumps? (*c*) Why do rivers running through level countries, such as the Neuce and Pamlico, or the Tar River of North Carolina, have no regular ebb and flow of the tide, while rivers running through other countries, such as the Delaware River and Hudson River do? (*d*) Please explain the principles of action of the centrifugal pump. J. E. T., Washington, N. C.

ANS.—(*a*) The pressure in the receiver of a compound engine acts as back pressure on the high-pressure piston. For instance, if the pressure on the steam side of the high-pressure piston is 125 lb. per sq. in., and the pressure in the receiver 50 lb. per sq. in., the net pressure on the piston is the difference between the two, or 75 lb. per sq. in. This effect is always shown by the indicator cards taken from compound engines. (*b*) Duplex pumps have one direct and one indirect rocker-arm, in order to secure the proper relation between the strokes of the two sides. Without such an arrangement of rocker-arms, both pistons would come to rest at one end of their stroke, and the pump would stop. (*c*) We do not know what causes the difference in the relation of the tide to the rivers of which you speak. (*d*) A very brief outline of the theory of centrifugal pumps is the following: The rapid rotation of the blades of the pump gives the water in the pump a very rapid rotary motion. The centrifugal force of this rapidly rotating mass of water tends to carry it out of the pump at the circumference of the blades and drive it out through the discharge pipe. In many centrifugal pumps, centrifugal force is aided by an

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action of the blades that somewhat resembles the action of the screw. The blades are curved in such a manner that they tend to push the water outward toward the circumference as they revolve.

***

(316) (*a*) If the distance from *m* to *n* by a straight line is 20 miles, the highest point being 5 miles, what is the distance by the curved line? (*b*) Can a separate call bell be connected to a private (two-wire) telephone line?

H. T. M., Manchester, N. H.

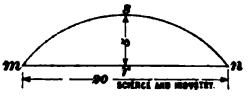

FIG. 1

ANS.—(*a*) Assuming the curve in Fig. 1 to be the arc of a circle, its exact length, calculated by trigonometry, is 23.12 miles. The length of the curved line may be calculated approximately by the formula, $l = 2x\left[1 + \frac{2}{3}\left(\frac{y}{x}\right)^2\right]$, in which $x = \frac{1}{2}\ m\ n = 10$, and $y = r\ s = 5$. This will give $l = 23.33$ miles. (*b*) If you mean an extra bell, called

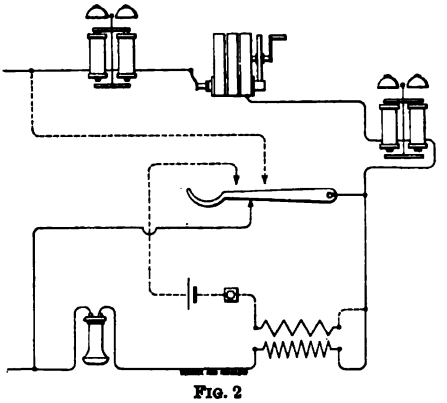

FIG. 2

an extension bell, to be rung by the telephone generator, then connect a bell of the same construction and make as the one now on your telephone, as shown in Fig. 2. The wires for this bell can be run to any part of the house. When the telephone generator at the distant end is turned, both the regular telephone and extension bells will ring. By using the ground as a return for a bell circuit, a separate bell may be arranged, as shown in Fig. 3, in which case the telephone and separate bells will not both ring at the same time. The earth could be replaced by a third wire, which would be necessary if grounding the line caused disturbing noises in your telephone. *G* and *C* represent ordinary telephone generators and bells. One generator and bell in the same box or case is known simply as a magneto bell. If the line is not too long, a third wire and a common vibrating or battery bell *V*, batteries *B*, and switches *l* could be used by connecting them as shown by the dotted lines. The switch *l* should have a stiff spring, which will insure its returning to button or contact *1* as soon as the hand is removed from it when through ringing. The vibrator on one of the bells *V* should be short-circuited.

***

(317) (*a*) What is the composition of the metallic powder that is used in a coherer for wireless telegraphy? (*b*) Where can I obtain it, and is it expensive? (*c*) How much powder would be needed for a small coherer?

R. B. O., Pennock, Minn.

ANS.—(*a*) The material is not a powder, but consists of filings, 96% of which is hard nickel and 4% silver. (*b*) We do not know where you can buy the filings, but you can make them easily. They should be as coarse as you can make them with a large rough file, which should be very clean and dry. (*c*) The inside diameter of the glass tube should be from $\frac{1}{32}$ to $\frac{1}{8}$ in., and the faces of the silver plugs should be separated from $\frac{1}{32}$ to $\frac{1}{16}$ in., and these intervening spaces should not be over two-thirds full of filings; consequently, only a very small quantity of filings will be needed. Amalgamate, with mercury, the faces of the silver plugs, which should fit nicely in the glass tube. If a permanent coherer is desired, it is said to be better to exhaust the air to $\frac{1}{760}$ of an atmosphere and seal the ends air-tight with a non-oxidizing (hydrogen) flame, in order to prevent the oxidizing of the silver plugs and filings.

***

(318) (*a*) I have on my locomotive a Sellers injector that gives considerable trouble, although recently repaired in the shops. When the tank (on the tender) is full, and the water level, therefore above the injector, the latter works all right, but in a short time it fails to prime readily and can only be made to do so by repeated efforts. The tank is perfectly clean. Is the injector taking steam in too great a volume, when set for priming? (*b*) What is the difference in construction between the Sellers and Monitor injectors?

A. M. S., Petersburg, Va.

ANS.—(*a*) The refusal of your injector to lift the water promptly after it gets below the level of the injector may be due to leaky joints in suction pipe or to a poorly packed water-valve stem, air thus entering the suction pipe and destroying the vacuum; or, the tank may be air-tight, which would prevent atmospheric pressure from entering the tank to force water to the injector. Also, leaky boiler and line checks will allow hot water to work back into the

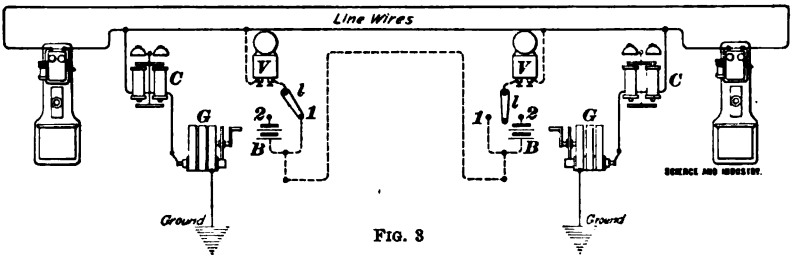

FIG. 3

suction pipe and prevent the injector from working, by giving off a steam vapor and destroying the vacuum in the suction pipe. It may be that the injector gets too much steam when priming, if the end of the steam-valve stem that enters the force nozzle has been reduced by wear or any other cause. When the water in the tank is above the level of the injector, the above defects will not affect its working so much as when it is below the level. (*b*) The

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construction of the Sellers and Monitor injectors is practically the same in principle, but the instruments differ somewhat in appearance, the shell of the Sellers being cast in one piece, and the Monitor in three. The steam valve and stem in the Sellers are in one piece; in the Monitor there are two valves, a lifting and a force valve, secured to the valve stem by a disk nut on the end of the valve stem. The lifting and forcer nozzle of the Sellers are screwed one inside the other, while in the Monitor the lifting nozzle is screwed into the forcer steam valve, the latter being in turn secured to the lifting valve by a shank and nut, a small relative movement being provided for. The combining and delivery tubes of the Sellers injector are long, with a gradual taper, and have three sets of spill holes; in the Monitor injector, the tubes are shorter and of a different shape and taper. In both injectors, the three tubes are screwed together, making one piece, and are put in from the discharge end of the injector, those in the Sellers being screwed in, while those in the Monitor are forced in and held in place by the check-valve case, which is screwed into the centerpiece. The line check of the Sellers injector is in the discharge end of delivery tube. The overflow arrangement on the Monitor is similar to that of the Sellers, the overflow valve being held to its seat by a screw stem while the injector is being used as a heater, whereas on the Sellers it is held down by a cam-lever. The water valve is virtually the same in both injectors.

***

(319) Some time ago, when repairing a medical coil, I found that it contained five layers of iron wire wound over the primary and connected to it. Over the iron wire was wound five layers of No. 36 copper wire, which was also connected to the primary. Please inform me as to the object of using the iron wire. I. C. W., Troy, N. Y.

ANS.—Judging by the size of the wire submitted, it must have been wound on the secondary and not the primary. The fine-wire coil is the secondary and not the primary. We do not see any benefit to be gained by winding part of the secondary with iron wire; in fact, if anything, it would be an objection. It may have been put on with the idea that the iron would improve the magnetic circuit, but as coils work best with an open magnetic circuit, there would be no gain by using the iron. It would probably be found that the coil would work as well, if not better, if wound with copper wire throughout.

***

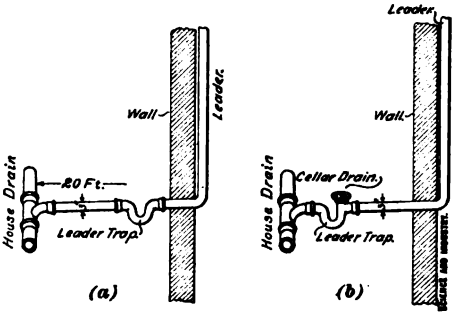
(320) (*a*) Why is it that when the light of the sun passes through a square hole, or a hole of any other shape, it always casts a round shadow? (*b*) How are metal utensils coated with granite or porcelain? (*c*) How may cooling effects be produced by electricity other than by the use of fans? (*d*) What books and pamphlets, other than those of the Agricultural Department, are distributed free by the government? S. T., Houston, Tex.

ANS.—(*a*) The explanation of the phenomenon why the sun's rays passing through an irregular hole will form a circular image on a screen beyond is too long to give in these columns. It will be found in any good textbook on optics. (*b*) The varieties of enamels for metals are so many and the methods of applying them are so different that we must refer our correspondent to "The Metal Worker's Handy Book," by William T. Brannt; price $2.50. This book can be purchased from The Technical Supply Co., Scranton, Pa. (*c*) Electric power is often used in producing cold in a manner exactly similar to the more frequent use of steam power. (*d*) The government furnishes an immense variety of books and pamphlets without charge. It does so, however, only to institutions, libraries, and private individuals that are likely to use them in such manner as to benefit the general public. Your congressman can give you effective help in getting anything of that kind.

***

(321) (*a*) How can I find out the quantity of water in the seal of a trap? (*b*) Give an every-day rule to find how long it will take a leader trap to lose its seal by evaporation, the trap being placed in the cellar. (*c*) Will a leader drain between the trap and main house drain, as per sketch (*a*), form a dead end? (*d*) If the leader trap is placed close to the main drain, as per sketch (*b*), would it make a better job, or would it siphon out by closet discharges? (*e*) Would there be any objection to placing a strainer over the handhole in the leader trap as per sketch (*b*), and using it to drain the cellar of any water on the floor? J. G. B., Greenville, N. J.

ANS.—(*a*) The quantity of water in the seal of a trap can be found by unscrewing the trap screw and



drawing off the water until the seal is broken. (*b*) There is no rule for determining the length of time it will take for a leader trap to lose its seal by evaporation. The rate of evaporation will depend on the humidity of the atmosphere, on the velocity of the currents, and on the temperature. (*c*) Yes; because no provision is made for its ventilation. (*d*) Yes; it will make a better job. We believe there will be no danger of its being siphoned out by the discharge of water closets unless the discharges are sufficient to fill the entire bore of the main house drain, which is an exceedingly rare occurrence. (*e*) We do not like the idea of placing a strainer over the drain pipe in the cellar, as shown, unless a separate trap is provided for this purpose, because during winter this strainer will constantly give off air into the building, which, even though it comes from a clean rain-water drain, is very objectionable. You should trap the strainer.

***

(322) Give me a good recipe for making shellac varnish for patterns. In this locality we use shellac gum flake and wood alcohol, together with lampblack, but the black does not seem to mix right in the varnish. W. T. T., Oklahoma City, Okla.

ANS.—First mix the lampblack in grain alcohol in a separate dish; dissolve the gum of shellac in the best grade of grain alcohol, and then compound these two mixtures by stirring until thoroughly incorporated. Some workmen simply dissolve the shellac in alcohol and afterwards add the lampblack, stirring until properly mixed; but the former method gives a better mixture, and is less liable to be "knotty."

***

(323) (*a*) A cast-iron disk 6 ft. in diameter and 12 in. thick is fixed on a shaft whose axis is the same as that of the disk. What force, acting with a lever arm of 3 ft., will give the disk an acceleration of 10 turns per minute, friction and weight of shaft being

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neglected? (*b*) A house is sold for $5,000 on payments of $30 per month, and $500 cash down. A part of each monthly payment goes to pay interest at 6% on the unpaid portion of the principal, and the balance of each payment is applied to the reduction of the principal; so that, the unpaid balance being steadily decreased, the part of each installment that is applied as interest will decrease, and the property will ultimately be cleared. How long will it be till the property is clear? Q. E. D.

ANS.—(*a*) Your question is not plain, as you do not state whether the acceleration referred to is 10 turns per minute *per minute*, or 10 turns per minute *per second*. According to the usual language of mechanics, however, we shall take your meaning to be 10 turns per minute per minute, which means that the rate of revolution at the end of every minute is 10 turns per minute greater than the rate at the beginning of the minute. Let F be the required force, p its lever arm, W the weight of the disk, and I its moment of inertia with respect to its axis. Also, let N be the acceleration of the disk in turns per minute per minute. Then,

$$Fp = I \times 2\pi N. \qquad (1)$$

All dimensions being in feet, we have $I = \frac{Wr^2}{2g}$, where r = radius of disk, and g = acceleration due to gravity *in feet per minute per minute* = 32.16×60^2. For W, we have $W = \pi r^2 \times 1 \times 450$. We can now solve equation (1) for F, which gives:

$$F = \frac{I \times 2\pi N}{p} =$$

$$\frac{\pi \times 3^2 \times 1 \times 450 \times 3^2}{2 \times 32.16 \times 60^2} \times 2\pi \times 10 \over 3 = 10.358 \text{ lb.}$$

(*b*) There are several approximate methods of solving such examples. The following solution is as simple as any of these, and is exact. Let A denote the number of dollars due after the cash payment, let B denote the number of dollars in each installment, and let the rate of interest be R per cent. per annum. Then, the number of dollars outstanding at the end of n months is

$$\left(A - \frac{1{,}200\,B}{R}\right)\left(1 + \frac{R}{1{,}200}\right)^n + \frac{1{,}200\,B}{R}.$$

If the property is clear at the end of n months, we have

$$\left(A - \frac{1{,}200\,B}{R}\right)\left(1 + \frac{R}{1{,}200}\right)^n + \frac{1{,}200\,B}{R} = 0.$$

Putting $A = 4{,}500$, $B = 30$, and $R = 6$, we get $n = 277$, nearly. Therefore the time is $23\frac{1}{12}$ yr.

***

(324) (*a*) Give all information at your command in regard to liquid air. (*b*) Recommend some book on the subject. (*c*) Explain how the clearance spaces are put in solid pipe dies and thick dies of similar design. J. H. F., Baltimore, Md.

ANS.—(*a* and *b*) See "Liquid Air," by T. O'Connor Sloane, price $2.50; or, "The Liquefaction of Gases," by W. L. Hardin, price $1.50. These books may be obtained from The Technical Supply Co., Scranton, Pa. (*c*) The clearance holes are usually drilled in and the cutting edges are finished by filing. Where a large number of dies are to be made, a jig is used for drilling the clearance holes.

***

(325) Please show me how to find the latent heat of 1 lb. of steam at a temperature of 78° F. I have tried to solve this from the steam tables, but have been unable to get a satisfactory answer.
J. C., Jr., Chester, Pa.

ANS.—A temperature of saturated steam of 78° F. corresponds to a pressure of less than ½ lb. per sq. in. absolute, while the lowest pressure given in many steam tables is 1 lb. per sq. in. Referring to one of the tables given in Roentgen's "Thermodynamics," we find the latent heat of 1 lb. of steam, at a temperature of 77°, to be 1,060.3944 B. T. U., and at a temperature of 86°, the next higher value given in the table, the latent heat is 1,054.1232 B. T. U. The decrease in latent heat for the increase of 86 − 77 = 9° in temperature is 1,060.3944 − 1,054.1232 = 6.2712 B. T. U.; consequently, the decrease for an increase of 1° is 6.2712 ÷ 9 = .6968 B. T. U. The difference between the lower temperature from the table and the temperature at which the latent heat is to be found is 78 − 77 = 1°; consequently, the required latent heat is 1,060.3944 − .6968 = 1,059.6976 B. T. U.

***

(326) (*a*) Would it be practical to put up a private telephone line from our mills to our residence and stables, a distance of 1½ miles? We could use standing trees for poles, if they would serve the purpose. (*b*) What system would be best? (*c*) What would be the expense, exclusive of construction and wire? (*d*) Would any source of power other than batteries be required? W. H. P., Elton, La.

ANS.—(*a*) It would be practical. You can use the trees for poles, but the foliage must be trimmed away and the wires supported on insulators, so that the wires cannot touch the trees or foliage, especially when wet. (*b*) Use two hard-drawn, bare, copper line wires, No. 14 B. & S., and either what are known as series-magneto-bell or bridging-magneto-bell telephones. Bridging telephones would be the better, but in your case, where only three telephones are on one circuit, series telephones will be satisfactory. (*c*) Series-magneto-bell telephones will cost from $11 to $16 apiece, depending on style and make, and the bridging-magneto-bell telephones $3 or $4 apiece more. The cheapest in first cost will not be the most satisfactory or cheapest in the long run. Get good, reliable telephones. If your line wires are near or across trolley or electric-light wires, you should have a strong current or fuse protector, in addition to a good lightning arrester, at each telephone. They should not cost you over $1.25 apiece, and probably less. There would be no other expense outside of the line wire, insulators, wood brackets, and the erecting of the line. (*d*) No. Two good Leclanché cells at each telephone will furnish all the power required. Do not use dry cells.

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(327) In "The Building Trades Magazine' of March, 1899, page 182, the statement is made that tin should never be laid on a wet roof. (*a*) Is this correct when the tin is well covered with paint on the under side? (*b*) When does water begin to expand during the process of freezing? (*c*) Would you give me the address of some steel mill where I could get a handbook on the properties of structural-steel shapes? J. M., Belleville, Ill.

ANS.—(*a*) Even when tin is painted on the under side, it should not be laid on a wet roof, because it is impossible to prevent scraping the paint in laying, and, if moisture occurs under the tin, some initial corrosion is sure to take place. Moisture will not occur to any considerable degree on the under side of the tin from condensation, provided the roof is first covered with a waterproof roofing paper or felt, and, consequently, if the initial corrosion is prevented, there is little likelihood of the tin being destroyed from the under side. (*b*) Water, when reduced in temperature, contracts in volume until it reaches 39.2° F.; from there it expands until it reaches 32° F., at which point it freezes. Water changing from a liquid to a solid increases in volume about one-ninth. (*c*) "The Building Trades Pocketbook," which can be had for $1.50 by addressing The Technical Supply Co., Scranton, Pa., contains extensive tables of the properties of the usual rolled-steel sections. Similar tables can be had by addressing The Pencoyd Iron Works, Philadelphia, Pa.; The Passaic Rolling Mill

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Co., Paterson, N. J.; The Carnegie Steel Co., Pittsburg, Pa. These concerns will, however, charge you for their books unless you are a buyer of such material as they manufacture.

***

(328) (*a*) Explain whether the steam gauge in common use registers pressures above or below that of the atmosphere. (*b*) What is meant by *absolute pressure*? (*c*) How high should the water be kept above the level of the flues or the crown sheet for safety? (*d*) What kind of a machine shop would you recommend me to go into to learn engineering? Do you think a marine shop is preferable to a repair shop? K. M. T., Logan, Ore.

ANS.—(*a*) As commonly made, a steam gauge registers pressures above that of the atmosphere. The pressure registered is then called *gauge pressure*. (*b*) Absolute pressure is pressure reckoned from the point of no pressure, i. e., a perfect vacuum. (*c*) This would depend somewhat on the design of the boiler and the rapidity of evaporation. In general, we would not recommend you to carry less than 6 in. of water above the flues. For special cases, however, more or less water may be carried without danger. (*d*) We presume from your inquiry that you wish to become a marine engineer. In that case, we would strongly recommend you to enter a marine shop, since a three years' apprenticeship in such a shop is, by United States laws, considered the equivalent of two years' sea service; three years' sea service being prescribed prior to application for license.

***

(329) Why is it that pipes conducting hot water will freeze more quickly than those conducting cold water? I know there is a good scientific reason for it, but have not a thorough understanding of the matter. J. S. O., Cincinnati, Ohio.

ANS.—It would appear that water that has been boiled and allowed to cool to the same temperature as an equal volume of cold water, will freeze quicker than the cold water when both, otherwise under the same conditions, are subjected to the same influences. At least many members of the plumbing trade claim this to be a fact. It is quite possible that the solidifying process is facilitated by the absence or scarcity of air in the water that has been heated, and, presumably, by the absence of animal life in the water. When water is boiled, the air and other gases contained in the water are given off, and animalcules, to a large extent, are killed by the high temperature. In cold water, the animalcules imperceptibly agitate the water and no doubt help to prevent its solidification; and the absence of gases in the cold water that has been boiled presumably allows heat to pass rapidly from the particles of water. Some of our practical readers that have had experience in repairing frozen pipes may have better theories. If so, we would be pleased to have them presented in SCIENCE AND INDUSTRY.

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(330) (*a*) What is the proper way to level up a transit or a level? Are the leveling screws to be screwed as tight as possible? Give explanation in detail. (*b*) Describe the principle of the construction of ball bearings. I believe there are two kinds; explain both in full. (*c*) Is it true that printed matter photographed from an original copy of type is injurious to the eyes? J. W. L., New York.

ANS.—(*a*) The tripod legs should be planted firmly into the ground in such positions as to bring the tripod head approximately level and the plumb-bob over the given point. If the transit has no shifting center, the plumb-bob must be brought exactly over the point in setting the tripod legs, but if it has a shifting center this need be done approximately only; then, by loosening the leveling screws, it can be brought exactly over the point by means of the shifting center; the leveling screws should then be tightened moderately in order to hold the instrument in position. The centers should then be unclamped by loosening the lower clamp screw, and the instrument turned so as to bring the two plate levels parallel, respectively, to the two pairs of leveling screws, assuming that the transit has four leveling screws, as is the case with ordinary transits. Each pair of leveling screws should then be manipulated in turn, grasping the milled head of each screw lightly between the thumb and forefinger of each hand and turning both screws at the same rate in opposite directions until the bubble is brought to the center of each leveling tube. The leveling screws should not be screwed severely tight during any part of the process, and should it be necessary to turn either pair of screws through a considerable distance, the other pair should be loosened so as to cause no undue strain. The leveling screws should be brought to a good firm bearing, but should never be tightened sufficiently to cause severe strain upon any part of the instrument. (*b*) An article entitled, "Journal Bearings," in the August, 1899, issue of "The Mechanic Arts Magazine," gives more detailed information on this subject than we can spare the space for here. (*c*) Not that we know of, provided the reproduction is well done, and good paper is used for printing.

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(331) How can I make a thermometer? I wish to use it in a dry-house. G. D. R., Cincinnati, Ohio.

ANS.—We would advise you not to attempt to make one. The operation is at best a difficult one, and the chances are that your instrument would not be satisfactory when completed.

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(332) Please explain "Horner's method" of solving equation (3) in Answers to Inquiries, No. 215, in the May, 1900, number. ALPHA.

ANS.—You will find Horner's method of solving numerical equations explained in an article of considerable length in the April, 1898, issue.

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(333) (*a*) We have an air pump with a 6" overflow. Can I raise the water from the pump to a height of 30 ft.? If so, what additional work will it make on the pump? (*b*) Can I use the air pump as a fire-pump? Its size is 8 in. × 12 in. × 12 in. (*c*) Please give me a rule for calculating the dimensions of friction gearing that can be used in place of miter gears. (*d*) Which transmits the most power, a crossed belt or an open one? (*e*) If two machines are belted from a countershaft, one being set directly under the countershaft, and the other in such a position that the belt leads from the countershaft to the machine at an angle of 45°, which belt will give the best results? (*f*) Please recommend a good book on gearing. R. D., Montreal, Can.

ANS.—(*a*) The additional work required to raise the water from your air pump to a height of 30 ft. depends on the quantity of water discharged. If you know the volume discharged in 1 minute, its weight can easily be calculated by multiplying the volume in cubic feet by 62.5, or in gallons by 8⅓. The weight so found multiplied by 30 (the height to which the water is to be raised) will give you the number of foot-pounds of work done in raising the water. To this must be added a certain amount, depending on the length of the pipe. It is probable that 10 per cent. added to the calculated quantity of work will give you the total work required to raise the water under most conditions. After you have found the total work, the horsepower required to do this work is found by dividing by 33,000. (*b*) It is possible that your air pump might be used as a fire-pump, but we doubt whether it can be successfully used for such a purpose. (*c*) A complete outline of

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the method of designing bevel friction gears would take more space than can be given here. We would suggest "Elements of Machine Design," by W. C. Unwin, price $2.00, as an excellent source of information on this subject. (*d*) A crossed belt will transmit more power than an open one. (*e*) The belt set at an angle of 45° will give much more satisfactory results than the other one. (*f*) An excellent book on gearing is "Odontics," by George B. Grant, price $1.00. The books named may be obtained from The Technical Supply Co., Scranton, Pa.

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(334) (*a*) Please give me rules for finding the speed and power of a Pelton or other impulse waterwheel with a single nozzle, when the quantity of water, the head, and the length of pipe are known. (*b*) The theoretical velocity of water through pipes is given by the formula $V = \sqrt{2gh}$; please give me the formula for calculating the actual velocity.

W. C. B., Henley, Cal.

ANS.—(*a*) In order to make an estimate of the power that can be derived from an impulse waterwheel using a given quantity of water with a given total head, it is first necessary to calculate the loss in head due to the friction of the water in the pipes. Let Q = quantity of water in cubic feet per second; H = total head on nozzle in feet; H' = part of the total head required to overcome frictional losses in pipe; h = pressure head at nozzle, equals $H - H'$; L = total length of the pipe in feet; and D = diameter of pipe in feet. The head absorbed in overcoming friction in the pipe is given approximately by the formula $H' = \frac{Q^2 L}{1{,}000\ D^5}$. The pressure head at the nozzle then becomes $h = H - H' = H - \frac{Q^2 L}{1{,}000\ D^5}$. The theoretical power of the water that flows from the nozzle, neglecting losses in the nozzle, is H. P. $= \frac{Q h}{8.8}$. Assuming the losses in flow through the nozzle and the frictional and other losses in the wheel to be 25 per cent. of the theoretical power, the actual power that will be obtained is H. P. $= \frac{.75 Q h}{8.8} = \frac{Q h}{11.73}$. The speed of the buckets of an impulse wheel should be equal to one-half the speed with which the water issues from the nozzle. The probable velocity of flow from the nozzle can be calculated by the formula $v = 8\sqrt{h}$. Having the velocity v' of the buckets in feet per second, which is given by dividing the value of v found above by 2, and the diameter d of the wheel in feet, the number of revolutions per minute of the wheel is given by the formula $n = 19.1 \frac{v'}{d}$. (*b*) There are a number of different formulas for calculating the actual flow of water through long pipes. All these formulas contain factors or coefficients that have been determined by experiments on pipes under different conditions. One of the simplest formulas of this kind is the following: $v = \sqrt{\frac{D H}{C L}}$; in which D = diameter of the pipe in feet; H = total head in feet; L = total length of pipe in feet; and C = experimental coefficient. For rough cast-iron pipes, whose diameters lie between 8 and 48 in., the value of C may be taken as .00065. For smaller pipes, the value of C is somewhat greater, ranging from .00072 to .00080. For smooth pipes, the values of C are approximately one-half of those for rough pipes.

***

(335) (*a*) Please give several ways to put the crank of an engine on the dead center. (*b*) How is the length of the connecting-rod determined?

J. B. C., Hernando, Fla.

ANS.—(*a*) While several ways of finding the dead-center position of the crank are in use, most are only approximate at best. Hence, we prefer to give but one way, which is exact, however. Turn the crank until it is near the dead center. Make a fine scriber mark on the crosshead, and, coinciding with it, make another mark on the guide. Make a mark in any convenient location on the flywheel rim. Set a tram to the distance from some fixed point in the plane of the flywheel to the mark just made. Then turn the crank ahead past the dead center until the marks on crosshead and guide coincide again. With the tram, make a mark on the flywheel, taking care to measure from the same fixed point. With a pair of dividers, divide the distance between the two marks on the flywheel rim into two equal divisions, and then turn the wheel until the marking point of the tram just coincides with the new mark midway between the first two marks on the rim. The crank will now be on the dead center. (*b*) In designing an engine, it is plotted out on the drawing board. In an actual engine, its correct length has been found when trial shows that the clearance is equal on both sides of the cylinder.

***

(336) (*a*) Please make a suggestion as to how I can install an arrangement of pipes to superheat the steam passing through a pipe that transmits steam to the jacket of an apparatus for heating asphalt. (*b*) Do you think that a coil of pipe in the combustion chamber of my boiler, which is a modification of the Scotch marine type, would be suitable for a superheater, and that it would be safe to operate?

W. L. S., St. Louis, Mo.

ANS.—(*a*) It is probable that a coil of pipe in the combustion chamber of your boiler would furnish as satisfactory a method of superheating the steam as anything that could be devised. This method will be safe and fairly reliable if it is properly installed and is carefully watched to prevent serious overheating. (*b*) No system of superheating that has yet been devised can be relied on, unless great care is taken to prevent overheating of the pipes during any period when the flow of steam through them is stopped.

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(337) (*a*) A says that the steam on the top of a slide valve does not put pressure on the valve unless there is an opening under it. Without the opening under it there is, he contends, only the weight of valve. B says that it does put pressure on the valve equal to the product of area and steam pressure per unit area. (*b*) A also says the underside of the valve has no pressure except that due to the area of ports multiplied by the steam pressure per unit area. B says the pressure is that due to all the surface exposed to the pressure multiplied by the steam pressure per unit area. Who is right? (*c*) What is the best way to balance a slide valve?

G. W. L., Spring Valley, Ill.

ANS.—(*a* and *b*) B is right. (*c*) Balance 55% of the total area of back of valve. By "back" we mean the same as your "top." As, however, valves often work vertically, inclined, or even upside down, it is better to use the word "back" instead of "top." As regards the details of a balanced valve, a request for a catalogue addressed either to the Richardson or to the American Balanced Valve Co.'s will doubtless bring you what you want.

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(338) (*a*) I have a drum armature that I wish to wind. It has 8 grooves in it, and there are 8 segments in the commutator. Please tell me where the brushes will touch the commutator. (*b*) I also have a drum armature that has 12 grooves and 12 commutator segments; how shall I wind it?

G. S. P., Dorchester, Mass.

ANS.—We take it for granted that both of these armatures are to be run in a two-pole field. (*a*) If the ends of the coils are brought straight out to the

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commutator bars, the tips of the brushes should be in line with the middle of the space between the pole tips, and the two brushes should be directly opposite each other on the commutator. (*b*) Wind down slot 1 across the back of the armature and up slot 7, thence across the front and down 1 again, and so on until you have wound slots 1 and 7 half full; tie the two ends of the coil together and mark them so that you can distinguish the beginning from the end. Then wind down 2 and up 8 until these slots are also half full; do the same with 3 and 9, 4 and 10, 5 and 11, 6 and 12. All the slots will now be half full. Continue on around the armature, filling the top half of slots 7 and 1 by winding down 7 and up 1, then wind 8 and 2, 9 and 3, 10 and 4, 11 and 5, 12 and 6. This completes the 12 coils. Connect the beginning of coil No. 1 to the segment opposite it, and connect the other end to segment No. 2. The beginning of coil No. 2 connects to segment No. 2 and the end to segment No. 3, and so on until all the coils have been connected and the end of coil No. 12 connected to segment No.1, thus closing the winding.

***

(339) (*a*) Explain how to find the pull in pounds that an electromagnet would have on a movable core, such as used in a Brush arc lamp. (*b*) If a certain number of lines of force passed through an armature at a distance from an electromagnet, would the armature be pulled with the same force as it would if it were in contact, provided the same number of lines of force passed through the armature when in contact? J. B., Central Falls, R. I.

ANS.—(*a*) There is no simple formula that we know of giving the pull exerted by a solenoid on its core. The pull depends upon so many different things that it is very difficult to calculate it beforehand, unless experimental data is at hand on which to base the calculations. There is a different pull for every different position of the armature. The pull also depends on the linear proportions of the solenoid. (*b*) Yes; the pull would be the same if the number of lines were the same, and *if their method of distribution were not altered in any way.* If bringing the armature in contact changed the density of the lines, the pull would be different even if the total number of lines remained the same. Of course, in most cases, bringing the armature in contact greatly increases the number of lines passing through it, and the result is that the pull is greatly increased.

***

(340) (*a*) In setting a picket fence, board fence, post fence with rails, or a stone wall, for the division line between properties, what portion of the fence in cross-section is on the line? (*b*) Also for the same kind of fences, what portion is on the line when fronting a highway? I would like to know what measurement to make in order to accurately determine the width of the street at any point.

P. N., Stamford, Conn.

ANS.—(*a*) This will depend largely on the purpose for which the fence is built and the intention of the builder. If the fence is built jointly by the owners of the properties between which it is situated, it will usually, by mutual agreement, be so placed that the center line of the cross-section, if a wall or a fence having a symmetrical cross-section, or, possibly, the face of the posts, if a picket fence, will be on the division line. If, however, the fence is built wholly by one of the property owners, and he desires to own and have full control of it, it must stand entirely on his own property, no portion of it projecting over the line. (*b*) When the fence fronts upon a street or highway, the extreme outer face should be on the property line. We have observed, however, that many street fences which are built "exactly on the line" are not uncommonly placed with the faces of the posts on the line, while others are entirely over the line and into the street. The width of a street can seldom be determined accurately by measuring between the fence lines.

***

(341) Show me how to determine the E. M. F. of an induction coil, i. e., the E. M. F. generated in the secondary. H. B. W., Canton, Ohio.

ANS.—The easiest method of obtaining an approximate idea of the E. M. F. generated by the coil is to note carefully the distance through which it will set up a spark in air. To do this, arrange two perfectly clean needle points so that the distance between them can be readily adjusted and measured. Gradually move the points nearer together, until the spark jumps, and then measure the distance. By comparing with a table giving sparking distances, you can then form an idea as to the voltage. It must be remembered, however, that the sparking distance depends somewhat on the condition of the atmosphere, shape of the E. M. F. wave furnished by the coil, etc., so that the exact value of the voltage cannot be expected. The exact voltage could be obtained by means of an absolute electrometer, but such an instrument is not often available. The following are approximate values of the voltage and sparking distance between needle points (values given by Steinmetz): .25 inch, 4,100 volts; .5 inch, 9,500 volts; 1.0 inch, 17,700 volts; 1.5 inches, 25,100 volts; 2.0 inches, 30,500 volts; 2.5 inches, 34,400 volts; 3.0 inches, 37,100 volts; 3.5 inches, 42,000 volts; 4.0 inches, 43,200 volts.

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(342) I am running a 200-kilowatt Westinghouse railroad generator, and would like to inquire as to the best method of taking care of the commutator. (*a*) What should be the tension on the brush springs? There are three brushes $2\frac{3}{4}'' \times \frac{1}{2}''$ in each holder. (*b*) What would be a good lubricant for the commutator? Give any further information necessary for taking care of the machine. M. J. E.

ANS.—(*a*) The pressure on the brushes should be from 2 to 2.5 lb. per sq. in. of contact surface; any increase in this pressure lowers the contact resistance but slightly, while, at the same time, it causes excessive heating and wear due to friction. The pressure on each brush would, in this case, be from $2\frac{1}{4}$ to 3 lb. You can tell what the pressure is by pulling the spring off the brush with an ordinary spring balance. Be sure to see that the brushes slide freely in their holders. (*b*) A small quantity of oil or vaseline, applied with a piece of canvas duck, is about as good a lubricant as any. Keep the commutator smooth by using No. 00 sandpaper occasionally; never use emery paper. Also see that the brushes have a good bearing on the commutator; if such is not the case, hold a piece of sandpaper (rough side up) between the commutator and the brush, and draw it back and forth until the brush is brought to a good seat.

***

(343) I am thinking of building a small generator to furnish a "jump" spark for a gasoline engine. The following are the dimensions: diameter of armature core, 2 in.; length of core, 3 in.; number of coils, 12; size of wire, No. 36 B. & S.; number of feet per coil, 100; making 1,200 ft. of wire on the armature. I intend using three permanent magnets to furnish a density of 50,000 lines per sq. in. The total air gap will be $\frac{1}{16}$ in. (*a*) Would it be practicable to use soft iron instead of cast iron for the pole pieces? (*b*) What would be the best kind of steel for the magnets, and how hard should it be? (*c*) How many volts would the machine generate when running 3,000 R. P. M.? (*d*) At what speed would it cause a spark to jump the $\frac{1}{16}''$ space in the gas engine? (*e*) Could a condenser be used in connection with the generator? Would it not tend to flatten the spark or cause a brush discharge at the points? (*f*) Of what surface area would you make the condenser? (*g*) Is mica the best material to use between the sheets of tin-foil?

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What is the best way to make the end connections to the sheets? (*h*) Could I construct a machine of about the same size as the above, but more efficient, by having the armature provided with two windings, one of which would supply direct current to the field, and the other an alternating current to the outside circuit? Would not the two windings on the armature interfere with each other? (*i*) In what ratio does the resistance of an explosive mixture change in relation to its density and temperature? Is there any law giving this relation? If there is, apply it to acetylene gas.

H. H., San Francisco, Cal.

ANS.—(*a*) Wrought iron would be better for pole pieces than cast iron. (*b*) Use tungsten steel. Heat it to a dull red and quench. It is not necessary to draw the temper. The magnets should be left hard. (*c*) With a density of about 50,000, the machine would generate between 500 and 600 volts, as near as we can tell from the meager dimensions you have given. You have not given the polar embrace or the style of winding you propose using. If you are going to make an alternating-current machine, we do not see why you use 12 sections in the armature. For the best effect, the turns should all be bunched in two large slots for a machine of this kind. We also doubt whether you can get anything like a density of 50,000 with permanent magnets. You probably mean that your total air gap is $\frac{1}{32}$ in. or $\frac{1}{64}$ in. on each side, because we think you would have considerable difficulty in making an armature run within $\frac{1}{128}$ in. of the pole pieces, which you would have to do to get a total air gap of $\frac{1}{64}$ in. Your air-gap density would probably not be over 20,000, if it would even reach that amount, and the pressure obtained would thus be more likely in the neighborhood of 200 or 300 volts. (*d*) To jump $\frac{1}{2}$ in. in the engine would require a sparking distance of $\frac{1}{12}$ in. in air, as it has been found from practice that, to have the sparking reliable, the sparking distance in the engine should only be about one-half that in air. For a $\frac{1}{12}$″ spark in air, you would require in the neighborhood of 3,000 volts, and it is out of the question to attempt to generate such a pressure with a small machine of this kind. If you wish a jump spark, you should generate at low pressure and use an induction coil or a spark made by means of a wiping contact used in connection with a spark coil. It would be almost impossible to insulate such a small machine for such a high pressure, even if it were possible to generate this voltage. An ordinary telephone magneto only generates about 70 or 80 volts. (*e*) A condenser could be used across the air gap. It would tend to give the spark more volume, which would be an advantage. (*f*) We do not know what size would be required; this must be determined by experiment. (*g*) Yes; mica is the best material, but it is so difficult to work into shape that waxed paper of good quality is used in most commercial condensers. Let alternate sheets of foil project out about $\frac{3}{4}$ in. at each end, beyond the paper, and press them together. The paper should be about 1 in. larger all around than the foil. (*h*) You could construct a machine this way, but it is a question whether anything would be gained. You would get a stronger field, but the extra winding would take up space on the armature that could otherwise be used for additional turns for the alternating-current winding. There should be no trouble due to the windings interfering with each other; the current in both the armature windings would be alternating. (*i*) The relation between the sparking distance and the voltage varies for different gases, and there is no rule for estimating the resistance for different pressures that would apply to all gases. Peace gives the following formula for air for sparks not under two millimeters in length: $V = 1{,}500 + 30{,}000\,l$, where V is the voltage, and l the length in centimeters. As stated above, it will usually be found satisfactory if a coil is provided that will give a spark twice as long in air as it is required to give in the engine. The resistance increases as the pressure increases, but not quite in direct proportion.

***

(344) I am operating a 60 H. P. boiler of the return-tubular type. It has 25 sq. ft. of grate area, and the stack is 60 ft. high, with a sectional area equal to the combined area of the boiler tubes. We desire to increase the steaming capacity of the boiler. Would an increase in the grate area or in the height or sectional area of the stack have the desired effect?

J. M. C., Sand Creek, Mont.

ANS.—Any method of increasing the draft, such as a higher chimney or a blower, would enable you to burn more coal per square foot of grate area, and thus increase the steaming capacity of your boiler. The grate area is rather small for a boiler of that rated horsepower; but, without knowing more about the conditions, it is difficult to say whether or not an increase would improve the steaming capacity without an increase in the strength of the draft.

***

(345) Please show how to find x, the radius of the circle $A\,B\,C$.

T. M. G., Marietta, Ga.

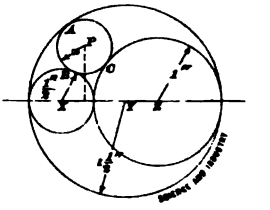
ANS.—Let $P\,Q$ be the perpendicular from P to $X\,Z$. Then, by elementary geometry, we have

$$\overline{X\,P}^2 = \overline{X\,Y}^2 + \overline{Y\,P}^2 - 2\,X\,Y \cdot Q\,Y. \qquad (1)$$

$$\overline{Z\,P}^2 = \overline{Y\,Z}^2 + \overline{Y\,P}^2 + 2\,Y\,Z \cdot Q\,Y. \qquad (2)$$

Multiplying equation (1) by $Y\,Z$, and equation (2) by $X\,Y$, and adding, we get

$$Y\,Z \cdot \overline{X\,P}^2 + X\,Y \cdot \overline{Z\,P}^2 = X\,Y \cdot Y\,Z \cdot X\,Z + X\,Z \cdot \overline{Y\,P}^2. \qquad (3)$$



From the figure, we have $Y\,Z = \frac{1}{2}$, $X\,Y = 1$, $X\,Z = \frac{3}{2}$, $X\,P = x + \frac{1}{2}$, $Y\,P = \frac{3}{2} - x$, $Z\,P = x + 1$. Substituting these values in (3), we have $\frac{1}{2}(x + \frac{1}{2})^2 + (x + 1)^2 = \frac{1}{2} \cdot 1 \cdot \frac{3}{2} + \frac{3}{2}(\frac{3}{2} - x)^2$, which reduces to a simple equation, and gives $x = \frac{3}{7}$.

***

(346) In Answers to Inquiries, No. 105, March, 1900, you mention the best way to dispose of the sewage from a certain building. I wish to know whether the same method would answer for a large sanitarium having three bathtubs and five closets. There is a leaching cesspool 200 ft. from the house, and the building is now properly fitted with traps. There is about 10 ft. fall to the cesspool, which is fitted with a loose cover. There is now trouble with stench when the wind blows toward the house.

O. B. P., Lebanon, Ohio.

ANS.—The system defined in the March issue will suit your case provided, of course, that the ground is loose and allows the sewage matter to freely filter away, and that no wells or springs are in the vicinity of the cesspool, to become contaminated by sewage seeping into them. You can prevent stench in the cesspool from blowing against the house by running a ventilating stack from the cesspool side of the main-drain trap up to and above the highest part of the roof of the house. The stench then instead of being emitted at the grating of the cesspool will be discharged to the atmosphere above the house.

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SCIENCE AND INDUSTRY

Vol. V AUGUST, 1900 No. 7

THE SPECTROSCOPE AND ITS WONDERS

G. H. Dimpfel, Ph. D.

IDENTITY OF FRAUNHOFER'S LINES WITH THE BRIGHT LINES OF INCANDESCENT SUBSTANCES. SPECTRUM ANALYSIS—COMPOSITION OF THE UNIVERSE

AMONG the many and startling discoveries and inventions, that of the spectroscope is certainly one of the most wonderful, and its application to chemistry, as well as to astronomy, has brought forth results that are far reaching and marvelous.

The discovery of the principles underlying the spectroscope dates back to 1675, when the famous physicist, Sir Isaac Newton, while investigating the nature and character of sunlight, found that a beam of sunlight, although apparently nothing more or less than the source of pure white light, could be split into a large number of rays of every imaginable variety of color. For this purpose, he admitted a single beam of sunlight through a hole in a shutter into an otherwise darkened room, and allowed the beam to pass through a simple glass prism, as shown in Fig. 1. The refractive power of the prism opened out the beam and displayed the gorgeously colored constituent rays that were until then united in one beam of white light. This decomposed beam of sunlight he called the *solar spectrum*, and he showed that in it the sequence of prismatic colors invariably range from red to orange, to yellow, green, blue, indigo, and violet, with every intermediate tint, one color melting, so to speak, imperceptibly into its immediate neighbor. He investigated other sources of light, and found that the display greatly varied according to the source of light, but that the colors were invariably the same for each kind of light.

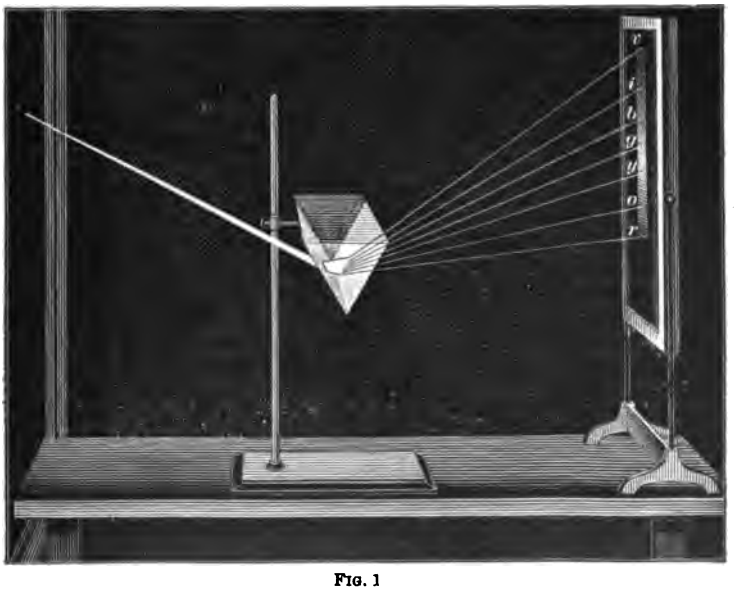

FIG. 1

After the solar spectrum had thus become familiar to every physicist, Dr. William Wollaston, in 1802, in experimenting with the spectrum, subjected it to a new test. As has been stated, Newton admitted the

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beam of light through a round hole; Wollaston gave it access to the darkened room through a narrow slit in a shutter, as shown in Fig. 2, and, on examining it after

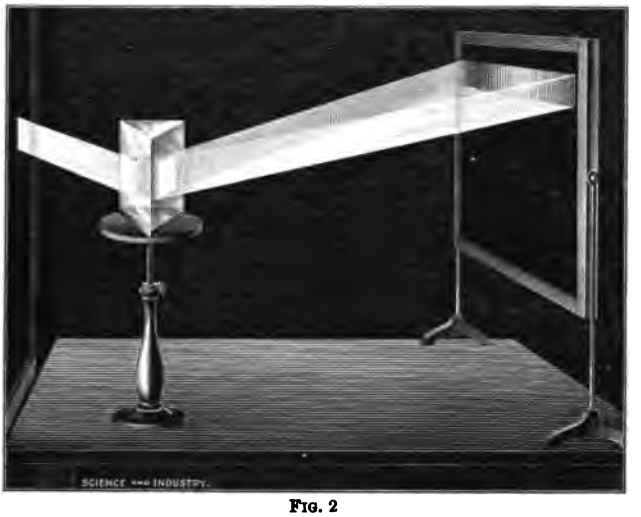

FIG. 2

deflection through the prism, he observed that the whole field of the solar spectrum, through all its sequence of colors, was scored down at irregular intervals by certain mysterious dark lines of more or less intensity. Out of this discovery eventually sprang into existence, about 25 years afterwards, one of the most marvelous applications of natural philosophy ever conceived by human ingenuity. Unsuspected by him, Wollaston, through his revelation of the dark lines in the spectrum, was throwing out the first hint for the building up of the now famous science of spectrum analysis.

In Wollaston's mode of conducting experiments, the prism was held close to the eye, sunlight being thus visibly deflected into a beautiful spectrum, ribbed from one end to the other with black lines at irregular intervals and of various thicknesses. Wollaston continued this investigation and subjected the electric spark and different colored artificial lights to a similar examination, but found bright instead of dark lines in the different spectra thus produced. Joseph Fraunhofer investigated these lines very exhaustively, and mapped them out so completely that they became known all over the world as "Fraunhofer's lines." All the prominent dark lines in the solar spectrum, which aggregate 354, each duly lettered and numbered, are clearly defined in Fraunhofer's publication. His final count was 576 lines, but other investigators have added to these, so that the grand total now amounts to 2,000. The more prominent of these lines, beginning with the red end of the spectrum, are designated in Fig. 3 by the letters *A*, *B*, *C*, *D*, *E*, *b*, *F*, *G*, H_1, and H_2. The illustration shows the visible portion of the sun's spectrum as it appears when dispersed with a single prism.

The most remarkable fact concerning these dark lines is that they are invariably the same, that is, they are in exactly the same place, of the same thickness, and of the same intensity. If the spectrum is seen when the sun is at the meridian, the dark lines in it reveal no variation whatever, either in their number or in the manner of their arrangement. It is only when the sun is rising or setting, and, consequently, when its beams penetrate horizontally through a greater thickness of the earth's atmosphere, that supplementary lines appear, which are obviously traceable to the influence of the atmosphere. Another remarkable fact is that the dark lines in the spectrum are identically the same in their relative positions in the different colors, whether the spectrum is derived directly from the sun, or indirectly by reflection from the moon or from one of the planets, while the spectra produced by the prism from the lights obtained from the fixed stars are entirely different. This circumstance clearly indicates that the dark lines in the spectrum of the sun and those of the fixed stars, being relatively or entirely different, cannot be attributed to atmospheric influences. More than this, a series of elaborate experiments has demonstrated the fact that a spectrum, marked vertically with bright instead of dark lines of a distinctive character, is produced through the prism from light produced by the ignited vapor of the chemical elements.

Doctor Ritchie has the distinction of being the first investigator to demonstrate that these dark lines are non-luminous spaces caused by absorption, which he made clear by artificially increasing their number. These lines are of such a reliable and permanent character along the whole sequence

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of the prismatically colored bands of the spectrum, that their most minute divisions can be referred to with the most absolute certainty, precisely as they were first laid down, in 1814, by Fraunhofer. Sir David Brewster, who carried his researches still further, insisted that the luminous band of the solar spectrum is divided into more than 2,000 visible and easily recognizable portions, separated from one another by lines more or less distinguishable, and, in 1822, while carrying on his experiments with the spectra of flames of different colors, he suggested the plan of using spirit lamps for this purpose, the wicks of which had been saturated with a solution of some salts, by which means monochromatic light might be readily obtained. Sir John Herschel extended these investigations, and, with the aid of the prism, examined red light produced by strontium chloride, the green light produced by copper chloride, copper nitrate, and boric acid, and he obtained the most beautiful results in the way of spectral elements. Long before this time it had been found that sodium compounds revealed a bright-yellow line in the spectrum, and it was then discovered that each of the known chemical elements possessed some distinct lines of various colors in the spectrum, and that very minute quantities of these elements could thus be discovered.

Fox Talbot, an English chemist, especially deserves credit in this line of investigation, and his name is closely connected with modern spectrum analysis. He suggested, in a remarkable paper published in 1826, the principle that "whenever the prism reveals a homogeneous ray of specific color existing in any flame, that homogeneous ray should be regarded as indicating the presence there of some definite chemical compound." Furthermore, in 1834, he stated that "optical analysis can distinguish the most minute portions of these substances from one another with as much certainty as by any other known method, if not more." In justification of this opinion, sodium, which is one of the most widely diffused elements known, betrays its presence instantaneously in the spectrum, the smallest particle of it, when ignited, producing the intensest yellow line.

Wollaston, in his experiments, placed his eye close to the prism, as has been previously stated; Fraunhofer improved this method by removing the prism 24 feet from the slit and examining the spectrum by means of a telescope. This improvement was so great that Fox Talbot, in 1834, was enabled to distinguish with perfect certainty between the otherwise apparently identical flame of lithia and strontia, and Prof. William Allen Miller was able to make a far-reaching investigation of the alkaline earth metals. He and Professor Wheatstone were the first to suggest, in consequence of the rigidly exact and unvarying position and character of the bright lines revealed in the spectra of differently colored flames, the adoption of spectral analysis as an infallible means of revealing the presence of any substance, no matter in how microscopically minute particles.

Thus the important discovery of Newton rested for some time, until Bunsen and Kirchhof, professors at the University of Heidelberg, astonished the world with their wonderful investigations and the marvelous results obtained from them. They found that groups of dark lines in the sun's spectra coincided with the bright lines given by iron vapor, and that other groups coincided with the bright lines of sodium vapor, hydrogen, and many other substances, and they inferred the existence of relatively cool masses of these vapors in the sun's atmosphere.

They devised the following experiment for showing the significance of dark-line spectra: Using the flame of a Bunsen burner, supplied with sodium vapor produced by the vaporization of common salt, they obtained the ordinary bright-line spectrum of sodium. Then, passing an intense beam of light from a calcium light through the Bunsen flame into the slit, it was found that the absorption of the sodium was such as to leave relatively dark lines in place of the bright lines given by the sodium flame alone, which indirectly proved their theory.

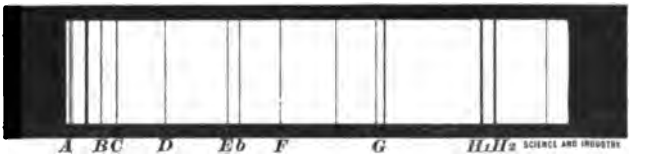

FIG. 3

Gradually, in accordance with the requirements of the experimentalists, the primitive means of investigation were improved until they developed into what is termed the *spectroscope*, a wonderful piece of mechanism

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designed for the better carrying out of these most delicate researches. Equipped with this instrument, modern science has done wonders. New elements have been discovered; the constituent elements of the sun, the comets, the fixed stars, and the nebulæ have been investigated and ascertained; and chemistry and astronomy have been united in restless research and discovery.

The spectroscope in its simplest form, as shown in Fig. 4, is a combination of a prism with three tubes. At the end of tube *a* is a narrow slit through which the light passes into the tube to a lens that throws it on the flint-glass prism *b* in the form of a narrow band. This prism refracts the light at a certain angle, depending on its color, and this line of refracted light is viewed through the tube *c*, which contains a lens and acts as a telescope. The third tube *d* contains a scale that may be thrown into the spectrum by the light *e* at the end of the tube. By this means, the spectrum, when viewed through the tube *c*, appears in connection with the scale, so that the exact position of the lines may be noted. The instrument is generally mounted on a brass support, as shown in the illustration. The entire spectrum, however, cannot be seen at once, hence the tube *c* is generally made so that it may be turned to bring the different parts of the spectrum successively in view. In some instruments, the tube *c* is made stationary, and the prism is so arranged that it can be rotated, thus accomplishing the same object.

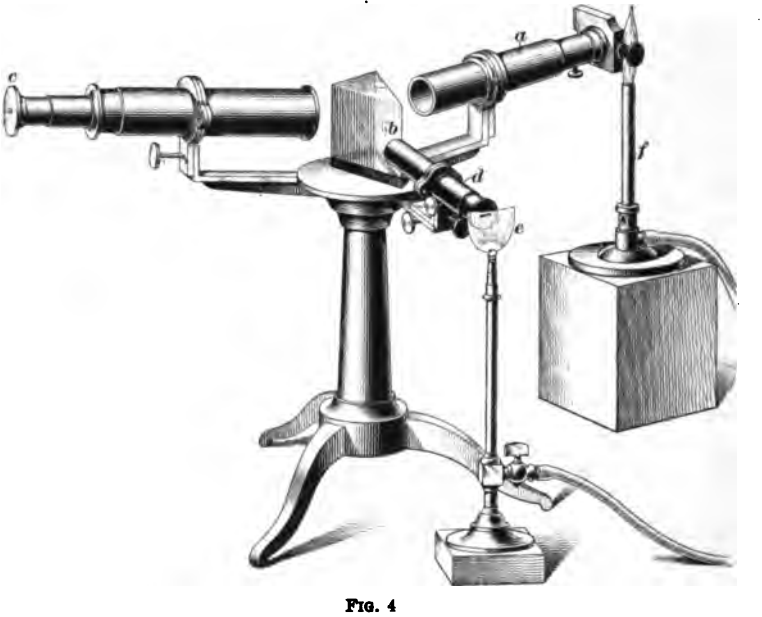

FIG. 4

While the spectroscope is in use, a black curtain is thrown over the prism and the ends of the tube, in order to exclude all extraneous light. The tube through which the light is admitted is 15 inches long, and the slit that serves as entrance for the light is about $\frac{1}{10}$ inch wide, and is made by placing two knife edges close together. The telescope is 18 inches long, and the eyepiece is furnished with a micrometer for observing accurately the dark lines or colored bands in the spectrum. A delicate vernier, which is a short graduated scale that slides along a lengthier one and thus indicates the fractions of division, is attached to the eyepiece, so that any dark or light lines may be accurately determined relative to the principal lines of Fraunhofer. The prism is placed between the object glass of the light tube and that of the spectroscope in such a way that it presents one of its edges to each, that in front of the light tube being parallel to the slit admitting the light at the other end.

This, in brief, is a description of the most commonly used instruments. For very delicate work, instruments with various improvements have been constructed, the best instruments being those in which the ray is passed through a series of prisms. An instrument having four prisms is shown

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in Fig. 5, but instruments are made having as many as twenty prisms. The object of increasing the number of prisms is to open out the rays, so that greatly increased dispersion is secured. By this great lengthening out of the solar spectrum, the dark lines are kept so far apart that an extremely delicate scale is formed, which greatly facilitates observation.

Bunsen's investigation led to his discovery of the element lithium, in 1860, that of thalium by William Crookes, and that of iridium by Richter. A worthy compeer and colleague of Bunsen, as has already been stated, was Gustav Kirchhof, whose exposition of the astounding facts, developed in rapid succession by his investigations with the spectroscope, at once made him famous.

Professor Nichol, more than 20 years previous to this time, in his "Architecture of the Heavens," had, with wonderful hyperbole, spoken of modern astromony as "carrying among the spaces of the fixed stars the precise tape of the surveyor, and dividing their intervals with mile stones." Seeing that the telescope had now called to its aid the agency of spectrum analysis, something far more wonderful was achieved than the mere measuring of interstellar distances.

With the aid of the spectroscope, scientific observers found themselves enabled to throw an entirely new light on the constitution of the universe. Although their researches in regard to the sun, for instance, could be carried on only across a distance of 90,000,000 miles, they were enabled, thanks to the newly constructed spectroscope and Bunsen's and Kirchhof's original researches, to discover the fact that in that remote orb existed at least ten metals that are common to it and to our own earth, namely, iron, sodium, potassium, chromium, magnesium, nickel, calcium, barium, copper, and zinc, while Kirchhof had already proved the presence of hydrogen in the solar atmosphere.

Applying the test of spectrum analysis to the comets and nebulæ, it was distinctly proved that they were nothing more substantial than enormous masses of glowing hydrogen, which, in a state of intense incandescence, were flying with inconceivable velocity through space. Starlight also has been examined, and it has been found that the stars are constituted very much the same as the dazzling center of our own system, yet the spectrum of each star so far examined shows that a marked difference exists between them.

How the physical constitution of the heavenly bodies can be deduced with such an absolute certainty from the revelations of spectrum analysis will now be explained in a few words.

It may be assumed as a matter of fact that light can be produced from anything that is sufficiently heated. The sun, the comets, the stars, and the nebulæ radiate light because they are in a state of absolute ignition. Knowing that light, however it may be produced, can be prismatically analyzed, the physicist and astronomer began to subject one thing after another to this searching kind of disintegration. It was found that every element, when its vapor was ignited, gave forth rays so peculiar to itself that it could readily be identified. All the spectra obtained from the light emitted by incandescent elementary substances differed entirely, and it was readily perceived that the bright lines characteristic of each correspond to groups of dark lines given by the solar spectrum.

That lights of various colors can be artificially produced is well known, and, but for this, displays of fireworks would lose half their attraction. Strontium, for instance, gives red light; barium compounds, a greenish light; sodium, a yellow; copper, a beautiful dark green; iron, an orange brown; lithium, a beautiful crimson; etc. Any artificial flame from a ray thus tinted, on being passed successively through the slit and the prism of the spectroscope, reveals unmistakable evidence of the existence, in the flame, of the element from which it has emanated; in fact, a well-defined spectral image is obtained, about the identity of which there can be no doubt whatever. As an illustration of this, a few of the metallic spectra may be here particularized. That of strontium shows six red lines, one orange, and one blue; that of lithium discloses two sharply marked lines, one of which is red while the other is yellow. Calcium makes itself apparent in its spectrum by several faint intermediate bands between a line of the brightest green and another of the most beautiful orange; barium is readily recognized by an array of bright-green lines, several yellow lines, a red, and an orange line.

The most remarkable fact in connection with the luminous-colored demarcations noticeable in artificial spectra, is that, in numerous cases, they coincide with the dark lines observed in the solar spectrum. Upon a critical examination and comparison of the spectra of the incandescent gases

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with those of the sun, the fact has been demonstrated that the position of the bright lines artificially produced is in exact harmony with the position of the dark lines in the solar spectrum, and from Kirchhof's memorable recognition of this dates the first knowledge obtained by us of the physical constitution of the sun's atmosphere. Not only one but a considerable number of elements possess bright-colored lines in their spectra that are positively identical with some of the dark lines observed in the sun spectrum.

Although, at first glance, an explanation of this curious identity between the bright and the dark lines might appear a difficult matter, it is a problem comparatively easy to solve, the generally accepted theory of the origin of the dark lines being that the light

FIG. 5

emanating from incandescent bodies in the act of passing through an ignited vapor is absorbed, and the rays thus absorbed are those that the burning vapor itself radiates. Thus, according to Kirchhof, the light emitted by the light-giving envelope, or photosphere, as it is usually called, of the sun, in darting forth from that great luminary, is so effectually absorbed by the vapors of various heated substances in the solar atmosphere that the only light that reaches the earth is that which has avoided absorption in passing through the solar vapors.

Immediately, therefore, on recognizing the fact that the dark lines in the solar spectrum were absolutely identical with the luminous-colored lines seen in the spectra of certain ignited elements, the deduction arrived at was that the vapors of these same elements must exist in the sun's atmosphere. Kirchhof, in 1861, wrote as follows: "In order to test, in the most direct manner possible, the truth of the frequently asserted fact of the coincidence of the sodium lines with the lines *D*, *I*, I obtained a tolerably bright solar spectrum, and brought a flame colored by sodium vapor in front of the slit. I then saw the dark lines *D* change into bright ones. The flame of a Bunsen burner threw the bright sodium lines on the solar spectrum with unexpected brilliancy."

Not satisfied with this demonstration, Kirchhof tells how he made another, the startling results of which he recounts as follows: "In order to find out the extent to which the intensity of the solar spectrum could be increased without impairing the distinctness of the sodium lines, I allowed the full sunlight to shine through the sodium flame on the slit, and, to my astonishment, I saw that the dark *D* lines appeared with an extraordinary degree of clearness." He further remarks that the phenomenon may be explained on the supposition that the sodium flame absorbs rays of the same degree of refrangibility as those it emits, and is perfectly transparent for all other rays. Further on, in support of this theory, he calls attention to the fact that nitrous acid and iodine vapor visibly possess this property of selective absorption.

To Kirchhof and Bunsen we are thus indebted for the application of spectrum observations to qualitative analysis. In the prosecution of their inquiries, they compared the spectra of the 50 elements then known with those of the sun, showing, as a result of these painstaking observations, that these familiar terrestrial elements of ours are widely diffused throughout the universe.

These two famous exponents of the spectroscope were followed by two Englishmen, William Huggins and Doctor Miller, who, scrutinizing the spectra of the comets, not only demonstrated the fact that these mysterious bodies are essentially different in every respect from the sun, but they also proved satisfactorily that Weinecke's comet was nothing more or less than an immense mass of carbon in a state of incandescence. Drawing in nebular light from the farthest observable abysses of space, they made plain, from the circumstance of their showing only

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a few bright lines in the spectroscope, that those mysterious sheeny lights in the heavens, the nebulæ, are nothing more than heated matter in a gaseous condition.

In many respects, the most wonderful of all Huggins's achievements in the way of applying spectroscopic research to the advancement of our astronomical knowledge is the fact that he determined with the utmost accuracy the motion of several of those almost indefinitely removed heavenly bodies that are only nominally fixed stars, and that lie in the outer depths of space at distances beyond the limits of the solar system which are hardly conceivable. This wonderful achievement was gained by observing the displacement of the dark lines in the spectrum derived from the pin-point like twinkle of one of those inconceivably remote luminaries.

So remote, indeed, are these fixed stars that the slender shafts of light received from them can only be opened out into a spectrum by passing them through a cylindrical lens placed in the focus of the object glass immediately in front of the slit. Without this artificial aid, the image obtained from the light through the prism of the spectroscope would have been nothing but a very thin line, without sufficient breadth to recognize the spectral lines. Besides this, the dispersive power of the spectroscope employed for this purpose was increased by the use of two prisms of very dense glass, and the spectrum thus revealed was viewed through a telescope of particularly short focal length. This telescope, moreover, was kept in motion by means of a clockwork during the time of observation, so as to insure the star, as far as the revolution of the earth upon its axis is concerned, as nearly as possible a stationary field of the spectroscope.

Examining thus the star Sirius, which is one of the nearest as well as one of the brightest of the fixed stars, Huggins discovered, purely through the displacement of the delicate lines upon its spectrum, that it is receding from us at the rate of approximately 26 miles a second, widening the gulf between the solar system and itself every year by many millions of miles. Thanks to the investigations of Huggins, we know that the orb of Sirius contains vast quantities of sodium and magnesium, that its atmosphere abounds in hydrogen, and that, though still one of the brightest of the fixed stars, it has for centuries been receding from the solar system at the rate of about 26 miles a second. Through the agency of the spectroscope, we have learned similar facts in regard to other stars at absolutely unmeasurable distances from us.

As amazing as the revelations already made by means of the spectroscope undoubtedly are, there can be no question whatever but that this comparatively young science of spectrum analysis is yet in its infancy. Who can forecast—who can even remotely conjecture—what may yet be the fruits of its development? So to speak, the two infinitudes, the infinitely small and the infinitely great, are open before it for investigation.

With the microspectroscope, a combination of the spectroscope and the microscope, very minute particles may be subjected to a scrutiny from the searching character of which there is no escape whatever. In proof of this, it will suffice to say that the thousandth part of a grain of blood is instantly detected from the unmistakable dark lines revealed by its spectrum. In fact, so delicate is the operation of the spectroscope, even without its power being increased by the supplementary aid of the microscope, that the smallest possible particle of salt, for instance, reveals itself by two intense yellow lines in the spectrum, or the merest trace of lithium by its two somewhat separated lines, one of which is red and the other yellow. Calcium discloses its presence by 75 lines in its spectrum, iron by 60 bright lines arranged in a peculiar fashion, etc.

One of the most prominent investigators of the day is Norman Lockyer, of England, through whose investigations an extraordinary amount of knowledge has been already acquired regarding the actual state of things in the sun. According to the revelation thus made through spectrum analysis as to the conditions of our great central luminary, it is now known that around the sun, though an immense distance from it, there is a cooler atmosphere, whence, in fact, comes the circle of light, or *corona*, as it is called, that visibly radiates into space in all directions around the hidden sphere at the time of a total solar eclipse. Nobody knows with certainty what this corona is. There are, of course, various theories, but none that is accepted by astronomers in general. Some of the greatest mysteries of the universe depend on the determination of this question, and the spectroscope may give us this information. If, as it is believed, this corona is a rain of meteoric dust, it will reveal itself in the spectroscope and show the same spectrum as the sun; if, on the other hand,

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it is a mass of glowing gases, their composition or nature will also be shown in the same way.

A total sun eclipse furnishes the most favorable time for observation of this and many other phenomena, for at other times the great luminary is like a flaming cloak to hide its secrets. A total eclipse of the sun took place on May 28, the period of totality varying in this country from 78 to 106 seconds. This is but a very short time, and it would not allow very extended researches were it not for the fact that the never-resting human ingenuity had brought forth photography as an aid of spectroscopy. The spectroscope and camera combined were used to great advantage, and the results thus mechanically recorded with absolute accuracy can be studied at leisure. To Prof. Henry A. Bowland, of Johns Hopkins University, Baltimore, Md., belongs the credit of bringing spectrum photography to its present state of perfection.

Besides the examination of the corona of the sun, there are numerable other problems of vital interest, one of the most fascinating of which deals with what astronomers call the *reversing layer* of the sun. This term is applied to the region in which exist, in the most favorable form, the gases that make the dark lines in the spectrum. Its position may be readily understood from a short statement regarding the generally adopted theory of the constitution of the sun. Our sun is supposed to consist of an interior part—a core, so to speak—of which little is known so far. It is, however, generally assumed that it consists of intensely heated gases. This core is surrounded by a shell of luminous vapors, the photosphere, as has been already mentioned, formed by the cooling and condensing of vapors on which the cold of the outer atmosphere has begun to have some effect. The reversing layer is just over the photosphere, and above it is the chromosphere, composed of uncondensable gases left unaltered by the condensation of the gases forming the photosphere.

This envelope has a rose-colored tint, and rises at times in large and flaming prominence, extending largely beyond the apparent surface of the sun. Outside the chromosphere is the corona. Although it appears certain that by no means does all the absorption of light, which, as we have seen, produces the dark lines in the spectrum discovered by Wollaston, occur in the reversing layer, yet it is a matter of vital importance to the spectroscopist. A total sun eclipse furnishes the most wondrous and beautiful spectacle that the spectroscopist can desire to see. When the moon advances across the face of the sun, it ultimately reaches a point when the photosphere appears to be entirely hidden; at this moment, the character of the spectrum changes—the spectrum of the sun through the reversing layer is no longer observed, but the spectrum of the reversing layer itself is visible to the eye, and bright lines instead of dark ones appear all over the spectrum. This layer is only about a thousand miles thick, and the opportunities for observing this phenomenon, generally known as the *flash spectrum*, last only a few seconds. It is probable that, on May 28, by the aid of the new appliances, photographs of the flash spectrum were taken which far surpass in interest and importance any ever before secured.

These spectroscopic studies of the sun are, however, not only of importance to the astronomer, for they touch the most fundamental problems and principles of science. The ordinary sun spectrum, for instance, does not show any trace of nitrogen, bromine, iodine, chlorine, boron, phosphorus, or arsenic, while the presence of oxygen is still doubtful. These elements occur abundantly on our earth, and as our globe is supposed to be originally a part of the sun, the question arises as to why these elements do not occur in the spectrum of the sun. Are they really elements and entirely absent from the sun, or are they decomposed through the influence of the temperature into still simpler bodies, and is our elemental theory at fault?

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REVOLUTIONS IN STREET LIGHTING

Alton D. Adams

OBJECTIONS TO ARC LAMPS—COMPARISON OF THE ELECTRIC ARC AND THE WELSBACH INCANDESCENT LAMP FOR STREET LIGHTING—INCANDESCENT ELECTRIC LAMPS

THE introduction of electric arcs on the streets of Paris in 1879, and at Wabash, Indiana, in 1880, marked an era in public street lighting. Prior to these displays of the electric lamp, street lighting was at its best with the simple gas flame, which yielded from 3 to 4 candlepower for each cubic foot of gas burned per hour. With electric arcs, the temperature of illuminating points jumped at once from that of the open gas flame to that of boiling carbon. The result was light of an intensity never before equaled by artificial means. Public attention was at once fixed on the new method of street lighting, and the demand for it grew rapidly.

During the last twenty years arc lamps have worked a greater revolution and induced a greater investment in street lighting than had been achieved by gas in half a century. Not only every city, but nearly all towns, if we except the smallest, have been wholly or partly lighted by electric arcs. In the important parts of most large cities, arc lamps have become the standard source of street illumination, and their number runs into thousands in many places.

In spite of, and to some extent because of, their rapid and extended growth in public favor, electric arc lamps have been the subject of much adverse criticism. Prominent among the objections to arc lamps for street lighting are the great lack of uniformity in the illumination produced, the strong contrasts between light and dark places, the extreme brilliancy of the arc from certain angles, and their cost.

Perhaps on no subject connected with electric lighting has there been more misunderstanding and misstatement than concerning the candlepowers of arc lamps. The nominal candlepowers of 2,000 and 1,200 that have been so generally stated have no definite connection with the intensity of light from electric arcs. Relying on these deceptive figures, and largely influenced by the effects of the electric arc on the eye, when located at certain points, those concerned in street lighting have placed arc lamps at much greater distances apart than are usual for gas and oil burners. The result in most places where electric arcs are used for street lighting is a number of luminous points of great intensity, to which the eye naturally turns, while the space to be illuminated is a patchwork of bright spots, dark areas, and still deeper shadows. The eye, shifting at rapid intervals from the source of illumination to the shadows, is confronted by extremes of light and darkness. These results are, to a large extent, inherent in street lighting by arc lamps, unless a sufficient number are used to make a high degree of illumination general. Some consideration of the structure and nature of arc lamps will make this evident.

An arc lamp consists, substantially, of a frame adapted to hold two carbon rods, and an automatic mechanism, electrically actuated, by means of which the carbon rods are moved together as they are disintegrated. The electric arc between the carbon points must be located at an intermediate point of the frame, and the closeness of the frame to the source of light causes a large shadow. A globe is necessary to protect the carbon points from storm and wind. If a clear glass globe is used, about 10 per cent. of the light is intercepted, and the shadows are much in evidence. Where an opal globe is used outside the lamp frame, shadows are largely avoided, but the intensity of the light may be reduced as much as one-half.

The electric arc between the ends of vertical carbon rods emits an intense light through an angular range of about 100 degrees, partly above but more below its horizontal plane. This angular field of intense light varies in position as to the horizontal plane through the arc, according as the lamp is operated with direct or alternating current, also according as the arc is open or enclosed. For the direct-current open arc, the angle of maximum light is from 40 to 50 degrees below the horizontal. If the direct-current arc is enclosed, the direction of maximum illumination is raised to within about 20 degrees of the horizontal, and may fall off but little between 20 and 60 degrees below the horizontal. The open alternating arc has a luminous field from

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about 60 degrees above to 60 degrees below its horizontal plane, but when this arc is enclosed, its field of maximum effect is contracted to about 100 degrees.

One cause for the general misunderstanding concerning the candlepower of arc lamps has arisen from the fact that the open direct-current arc yields a light that often reaches an intensity of 1,000 to 1,500 candles through a range of perhaps 5 to 10 degrees at 40 to 50 degrees below the horizontal. Now, the candlepower of artificial sources of light is computed as a mean of the intensity of light in every direction from the source, so that a high intensity through only a small field may correspond to a low mean spherical candlepower. This is just the case with the direct-current open arc, where, in a 500-watt lamp, the mean spherical candlepower is from 300 to 400, according to the condition of the arc and the kind of carbons used. These figures are for the bare arc, with no globe whatever; if a large outside globe is used, the light will be reduced from 10 to 50 per cent. The enclosed direct-current arc, so called from the small and nearly air-tight globe that surrounds it, yields about 225 mean spherical candlepower when operated with an opal inside and clear outside globe, the rate of energy consumption being 500 watts.

An enclosed alternating arc, consuming 500 watts, gives about 150 mean spherical candlepower with an opal inner and a clear outer globe. Arcs operated on series circuits, as above, are more economical than on constant pressure.

This reduction of arc-lamp candlepower to its mean spherical intensities, and the expression of its relation to the energy consumed, make possible a rational comparison with other artificial sources of illumination. During the past five years, attention has turned more and more from the brightness of electric arcs to the prevailing darkness over large portions of street areas that they are supposed to light. The truth that the desideratum in street lighting is uniform illumination is receiving more recognition. Means are being sought to make the dark places in streets brighter, even if the bright spots have their light diminished. To secure equally satisfactory effects with different systems of street lighting, each should be designed for equal minimum illumination at any point.

Gas street lighting has suffered far more displacement than any other by the introduction of electric arcs, but now gas is a far more effective lighting agent than it was twenty years ago. Then, the open batswing flame yielded a little more than 3 candlepower per cubic foot of gas burned per hour. Now, Welsbach burners give a mean spherical intensity of fully 12 candlepower per cubic foot of gas per hour. This great increase in the illuminating power of gas is now operating to displace electric arcs for street lighting. How far this displacement will go depends on several factors.

To appreciate the relative advantages of Welsbach burners and arc lamps for street lighting, where the minimum illumination is to be equivalent with each system, compare results and costs for Welsbach gas lamps burning 5 cubic feet per hour and open direct-current arc lamps consuming 500 watts each. The mean spherical candlepower of each arc lamp is about six times that of a gas burner in this case, so that for equal illumination at the darkest points, the arc lamps must be approximately 2.5, or $\sqrt{6}$, times as far apart as the Welsbach burners. This result is due to the well-known law that the intensity of light decreases as the square of the distance from its source increases, and $2.5^2 = 6.25$.

Owing to the requirement of gas lamps at all corners, when they are used, the proportion of Welsbach burners to arc lamps may be taken as 3 to 1. As each gas burner was assumed to require 5 cubic feet of gas per hour, the three burners, to replace one arc lamp, would consume 15 cubic feet hourly, at a cost of 2.25 cents when gas sells for $1.50 per 1,000 cubic feet. For a night of 10 hours, these three Welsbach burners, therefore, consume gas to a value of 22 5 cents, or about two-thirds of the amount paid, on an average, for a 500-watt arc lamp during an equal time. This comparison applies to arc lamps and Welsbach burners, without regard to the actual number of each, so long as their relative numbers remain such as to produce equal illumination of points most distant from lamps in either system. The figures given are rather favorable to arc lamps, because no account is taken of their shadows, and because the open direct-current arc, having a higher candlepower than any of the others on a given energy consumption, has been used as a basis. On the figures given, the advantage in cost of operation for incandescent gas lamps, over electric arcs, to produce equal minimum degrees of illumination, is so large as to furnish a strong inducement to the use of the former for street lighting.

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Changes in favor of Welsbach burners have already been made in a number of cities. In Europe, Munich is lighted with about 7,000 Welsbach burners; Berlin uses nearly 35,000 of the same illuminants, and Paris has substituted incandescent gas lamps on some of its most famous streets. It is reported also that Liverpool has discontinued electric street lighting from a municipal plant, and is using incandescent gas. In the United States, Welsbach burners are in use for street lighting, to a greater or less extent, in New York, Philadelphia, Baltimore, Washington, Cleveland, St. Louis, New Haven, Worcester, Richmond, and many other cities. Comparing present conditions with those of 1880, the time seems ripe for another revolution in street lighting; in fact, it has already begun. Of this revolution, it may be certainly said that it is against lamps of high candlepower, located at comparatively long intervals, so as to produce great variations in the intensity of street illumination at different points.

The kind of lamp to be used most generally in street lighting of the future is not so clear. Apparently, the most important systems to be considered are electric arc lamps, incandescent gas lamps, and incandescent electric lamps. Because arc lighting is proving unsatisfactory, as at present carried out, it by no means follows that it cannot be so modified as to retain a large part of the lighting on more important streets. At present, nearly all arc street lamps consume from 300 to 500 watts each, but arc lamps can be made in much smaller sizes if desired. The cost of an arc-lamp mechanism varies but little for any probable change in its capacity, and this fact operates to discourage the use of very small arcs. Again, the voltage required at the arc remains practically constant, whatever the candlepower, and the use of many small arcs would entail more expensive methods of distribution than are now common. Whether electric arcs, sufficiently reduced in capacity to compare with incandescent gas or electric lamps as to uniform distribution of light, can compete with them in price, remains to be demonstrated. That incandescent gas burners furnish any required degree of street illumination at the darkest points for materially less cost than the present arcs, is clearly established.

There remains for consideration street lighting by incandescent electric lamps. Unfortunately for the electric street-lighting industry, it has been thus far mainly carried on with short-filament low-voltage lamps in series, a system that has great inherent disadvantages. There is no good reason, however, why incandescent electric street lamps should not be operated at as high a voltage as those for interior use, with the consequent long filaments and far more satisfactory results from the standpoint of electric stations and the public. Such incandescent electric street lamps will certainly furnish any minimum degree of illumination at a less cost than the present arcs, and will seriously compete with Welsbach burners. Incandescent electric lamps can now be regularly had at from 10 to several hundred candlepower, the 16-candlepower lamp consuming 50 watts being the most common size.

Compared with the most efficient type of arc giving 350 mean spherical candlepower, the 16-candlepower incandescent lamp is to the arc in brilliancy as 1 is to 22. The arc lamps may, therefore, be $\sqrt{22} = 4.7$ times as far apart as the incandescent, so that, allowing a little for corners, there must be five incandescent lamps to give a minimum illumination equal to that from one arc lamp.

The cost of electrical energy, distributed at constant pressure, varies much with the size, duration, time, and constancy of the load. For motors, energy is sold in many places at 4.5 cents per kilowatt-hour, even to users of a few horsepower. At certain times of day, energy is sold for battery charging as low as 3 cents per kilowatt-hour. In case of the large, long, steady night loads of incandescent street lighting, at constant pressure, 4 cents per kilowatt-hour should give an excellent return to large electric plants. The five incandescent electric lamps necessary to replace one arc consume 250 watts, at a cost of 1 cent per hour, at the rate of 4 cents per kilowatt-hour. As a 500-watt arc lamp costs, on an average, about 3.5 cents per hour, it is 3.5 times as expensive as 16-candlepower incandescent lamps, for a given minimum degree of illumination; 60-candlepower incandescent gas burners were found to cost 2.25 cents per hour, when used to replace one arc, or 2.25 times as much as electric incandescent lamps. It may be said that the gas burners would make a better showing if used in smaller sizes, but it remains to be demonstrated that their high efficiency would be maintained were they reduced to 16 candlepower each.

In the present revolution in street lighting, there is much to indicate that arc lamps will find a deadly rival in their once vanquished enemy—gas.

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CONSTRUCTING A SHEET-METAL CUPOLA

(*Continued from the July, 1900, Number*)

William Neubecker

DETERMINING THE LENGTH OF THE SECTIONS—ASSEMBLING THE BASE MOLD—BRACING THE WORK FOR TRANSPORTATION AND ERECTION—PUTTING ON THE TIN COVERING

HAVING obtained the miter cut for the base, it will be necessary, before laying out the full pattern for one of the octagon sides, to determine the length required for the patterns. The exact measurements for the length of the sides are obtained by laying out a full-size plan of one quarter of the octagon, and, in order to draw this plan with accuracy, a trammel of sufficient sweep must be provided.

This trammel may be constructed from any scrap strip metal about 4 feet 6 inches long and 3 inches wide, by bending up on the brake ½ inch on each side, as shown at (*b*), Fig. 6. Holes 4 feet apart are punched in this metal strip, one being large enough to admit a pencil, as at *b*, while the other is simply made so as to insert a scratch awl, as at *a*; the awl is the center upon which the trammel turns.

The one-quarter plan, Fig. 6, can be laid out on a board or level floor as follows: Draw any line, as *b c*, and from its extremity draw the line *c d* at right angles to it. With the trammel, as previously described, using

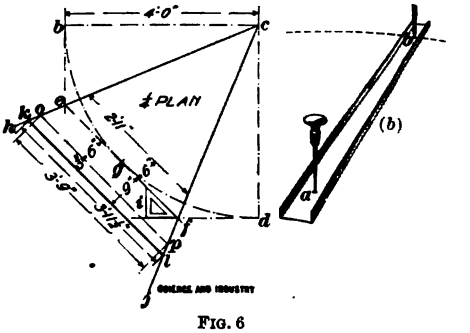

FIG. 6

c as a center, draw the quadrant *b d*. At right angles to *b c* and *c d*, and tangent to the quadrant, draw the lines *b e* and *d f*, respectively, and bisect the quadrant *b d* at *g*. Using a 45° triangle, placed in the position indicated as at *i*, draw the line *e f* tangent at *g* and intersecting the lines *b e* and *f d* at *e* and *f*. Draw, also, from *c*, two lines through *e* and *f*, extending them to *h* and *j*; these represent the miter lines.

From the section *F*, Fig. 3, it will be observed that the projection from the center of the column to the inner surface of the base mold is 9 inches. Therefore (in Fig. 6) lay off, perpendicular to the line *e f*, which represents one side of the octagon upon which the columns are centered, a distance of 9 inches, and through the points thus obtained draw *k l* parallel to *e f* and intersecting the miter lines at *k* and *l*. The distance from *k* to *l* is found by measurement to

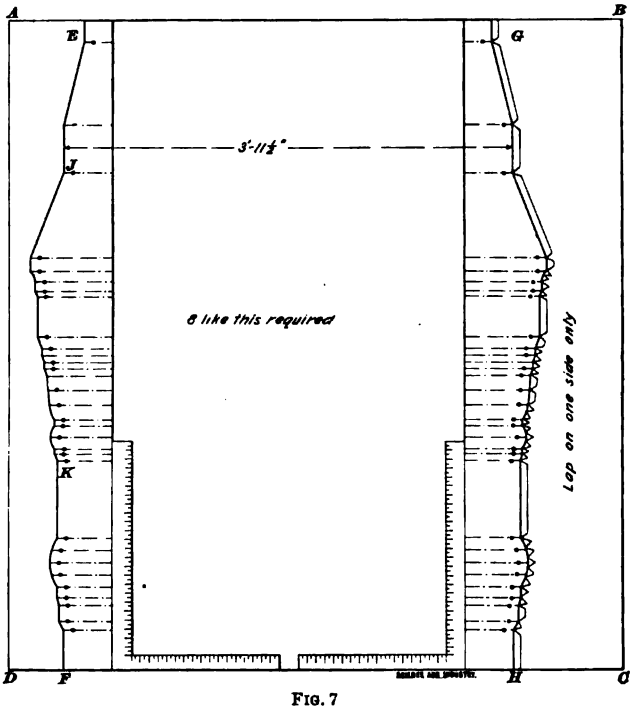

FIG. 7

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be 3 feet 11½ inches, and the measuring point on the pattern is at *R*, Fig. 4.

The profile of the miter cut and the length measurements are now all obtained, and the actual work of construction can proceed. In Fig. 7 is shown a sheet of metal *A B C D* laid on the top of a bench, with the side *D C* perfectly straight and true. The miter cut, shown by *M R P N* in Fig. 4, has been transferred to a piece of sheet iron and cut out, thus forming the templet, or pattern, represented in Fig. 7 by *E F*. This pattern is placed square on the sheet by laying the vertical side edge of the pattern at right angles to the trued edge of the sheet. The miter cut *E F* and the necessary dots are then marked off; the dots indicate where the bends are to be made. From *J*, which is the measuring point of the base, lay off 3 feet 11½ inches, and reverse the pattern, marking the profile *G H*, and putting in the dotted points for bending. Upon removing the templet, or pattern, cut out with the shears the sharp profile *E F*, as shown; in cutting the other end of the sheet, allow the laps, as at *G H*.

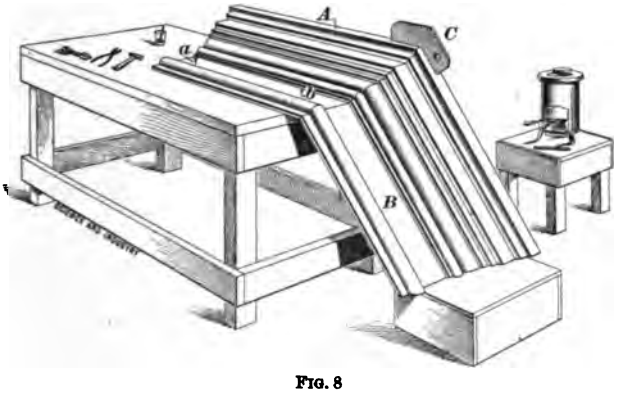

FIG. 8

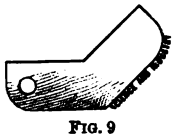

FIG. 9

If the base is made in three sections, joined by two seams, as previously mentioned in connection with Fig. 4, the lengths of the sections can be readily obtained. For, since the seams are placed at *S* and *S*, as shown in Fig. 4, which correspond with the positions *J* and *K* in the pattern, Fig. 7, the length of the top of the middle section is the same as the bottom of the first section, namely 3 feet 11½ inches, while the length of the third section is equal to that of the middle section at *K*; so that, when the entire pattern is laid together upon the floor, the miter cut will be continuous, as shown from *E* to *F*.

There will be eight pieces required, as designated in Fig. 7, and they must be all formed one way; that is, all laps to the right, according to the profile *C D E*, Fig. 4. This having been accomplished, it remains to join the several pieces forming the octagon so that the base will be in halves. To proceed with the joining of the molded sections, lay one piece on the bench face upward, with one end projecting over the end of the bench, as shown at *A*, Fig. 8, and fasten it to the bench with two small roofing nails *a* and *b*, which keep the molding from moving. Place another piece of the molded base in the correct position, being careful to see that it has the proper angle indicated by the stay *C* that has been previously laid out and formed, as in Fig. 9. This stay, or angle templet, is held on each member of the molded surface by the workman, while the helper tacks the seam with solder. When the entire miter has been properly tacked, it is taken from the bench and riveted, where convenient, with 2-pound tinned rivets, and then soldered on the inside, care being exercised in order that the tacks may not be loosened. In this manner, the four quarters are built up, and then two quarters are joined in order to form the halves.

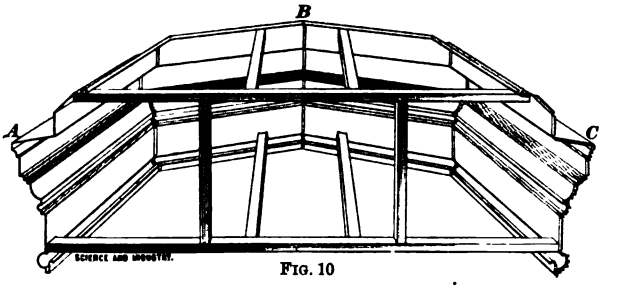

FIG. 10

When the two halves are finished, they are braced as indicated in Fig. 10, in which *A B C* shows the half base, braced by wood strips so that it can be delivered and hoisted

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without injury to the place it is to occupy. In erecting the base, or in fact the entire cupola, the scaffold used by the carpenter or framer is also used by the sheet-metal worker.

In Fig. 11, the manner of fastening the base to the wooden framing is shown. *A* and *B* are the side and floor rafters, sheathed on the outside with 1-inch stuff. The framer usually receives a detail copy of the base mold, so that he will be able to correctly set the necessary blocking, as at *a*. After this blocking is in place, the molding

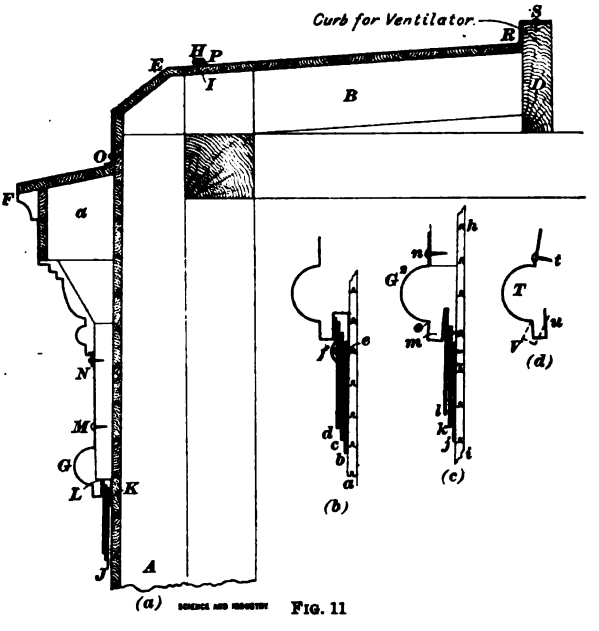

FIG. 11

is slipped over the woodwork, as shown by *E F G*. A lock is placed at *H* and nailed at *I*, while the lower part of the cornice is nailed at *K*. It will be noticed that a drip is placed at *L*, under which the slates are bedded in paint skins. The molding must be fastened at intervals by means of ¼-inch wood screws placed at such locations as *M*, *N*, and *O*.

The floor of the cupola is covered with old method 14″ × 20″ tin plate, locking into the lock *H*, as at *P*, and flashing up the curb *D*, at *R*; the nailing is to be pitched 1 inch along the line *S*. The tin roof will be soldered, using rosin and a 10-pound soldering copper, while *killed acid* should be employed where the tin joins the galvanized iron or copper. This acid is prepared by cutting zinc in muriatic acid, which agitates the acid; when the proper quantity of zinc has been added, the agitation stops, and it is ready for use.

The manner in which the slates are fastened after the base mold has been set is shown in diagram (*b*), Fig. 11. In this figure, *a* is the sheathing; *b* the first, *c* the second, and *d* the third slate; the slates are held in place by the nail *e*. Since the head of the nail is exposed, it is likely to cause a leak in rainy weather unless some precaution is taken to prevent it. Some roofers make a poor job of this in attempting to prevent such leakage by puttying over the nail head with a mixture of paint skin and putty that soon dries out, cracks, and falls off, thus failing in the desired result. A far better way to accomplish this is to put in an apron flashing, as shown at *f*, springing it well, so that when pushed between the drip and slate it will hold snugly.

In (*c*), Fig. 11, is shown how the drip of the base mold is secured against the slating if the base is slated first. The sheathing is designated by *h i*, and the slating by *j k l*. The base mold at the bottom is bent as shown at *m*, and fastened with wood screws at *n*. When making the bend at *o* it should be bent as shown in diagram (*d*), at *T u*; for then when it is fastened by the screw *t*, *u* will draw or spring tightly against the slating, as shown somewhat exaggerated at *V*

(*To be Continued.*)

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HINTS FOR ENGINEERS

W. H. Wakeman

IMPORTANCE OF ATTENTION TO DETAILS—PIPING AN EXHAUST-STEAM INJECTOR—LUBRICATING A DAMPER REGULATOR

WITH the adoption of the more delicate appliances for assisting the fireman and engineer in the operation of his plant, many devices are introduced that can be successfully operated only by the most careful attention to details. If these devices are properly installed and intelligently and carefully managed, they will give the most gratifying returns in the form of an increase in safety and economy and a decrease in the heavy labor and drudgery of the fire and engine room. Without such intelligent care, any attempt to use the more delicate devices is sure to result in a disappointing failure, in which case the user is far too apt to blame the principle on which the device is constructed as being wholly impracticable. The two incidents cited below will serve to illustrate these remarks, and will, perhaps, aid some engineer in his efforts to overcome the difficulties he has met with in attempting to use similar apparatus.

The action of the ordinary live-steam injector proves to be a puzzle to the student, but that of the exhaust-steam injector is still more surprising. The former takes water from a tank and puts it into a boiler against the same pressure that operates it, in addition to overcoming the friction in the pipes, etc.; the latter utilizes steam at atmospheric pressure, and puts water into a boiler against 60 pounds pressure. It will here be shown that there is a wrong way to pipe one of these boiler feeders, which results in complete failure to operate, and that a change

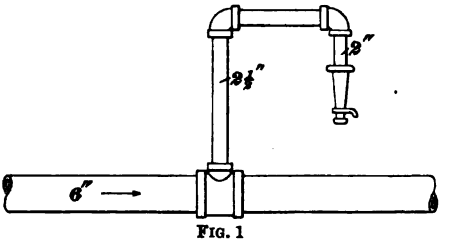

FIG. 1

in the arrangement of pipe and fittings is all that is required in order to secure satisfactory results.

Fig. 1 shows an arrangement of piping that proved unsatisfactory. The horizontal pipe is 6 inches in diameter, and the T in it is 6 in. × 6 in. × 2½ in. Where the pipe enters the injector, it is 2 inches in diameter. The steam discharged from the engine traveled along the 6-inch pipe in the direction indicated by the arrow. There was no

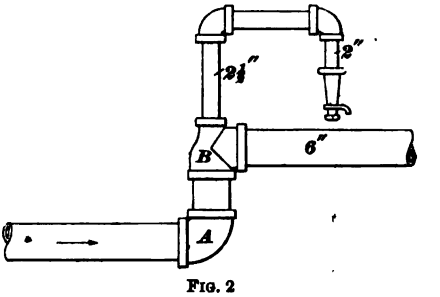

FIG. 2

back-pressure valve in the exhaust pipe, because it was not advisable to put an unnecessary load on the engine; hence there was no pressure to force the steam into the upright 2½-inch pipe, but, on the contrary, the tendency was to leave it empty, or nearly so. Failure for this plan was predicted before it was put into service, or rather before an attempt was made to use it, but it was not heeded, and useless expense was incurred, which readers of this article may avoid under similar circumstances, if they will profit by the experience of others.

Fig. 2 illustrates a plan that was successful under exactly the same conditions, with the exception of the change noted in the 6-inch piping. The 6 in. × 6 in. × 2½ in. T was taken off and an L put in its place, as shown at *A*. This was followed by a nipple and a 6 in. × 2½ in. × 6 in. T, shown at *B*. The 6-inch pipe was then continued as before.

By this plan, the steam passes into the 2½-inch pipe and thence to the injector, keeping the boiler feeder fully supplied with all the steam that it can use. The rest passes out of the 6-inch pipe into the atmosphere. Careful attention to details of this kind when piping up a machine usually proves to be a paying investment.

The ordinary damper regulator, which is operated by water under pressure, works nicely until impurities in the water cause

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corrosion, which prevents the mechanism from moving freely; then it becomes necessary to disconnect the parts and clean the valve and its stem. This must be done more or less frequently, according to the impurities in the water used and the service required of the regulator. In order to prevent corrosion, it is the custom of some engineers to introduce a piece of hard soap into the sediment chamber, which is shown at *B* in Fig. 3; this slowly dissolves and is expected to keep the parts in contact with the water free from corrosion. I think that his process is patented and that the right to use it may be purchased for five dollars. However, this plan does not compare favorably with the one that I have in use in my engine room.

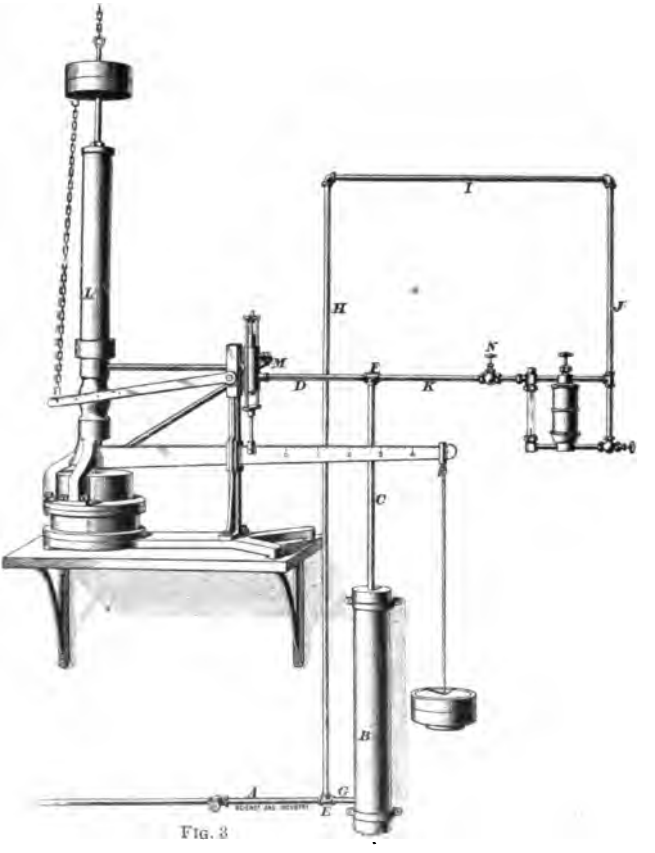

FIG. 3

Having decided to provide a way to inject kerosene oil into this water, in order to clean the parts, or any other kind of oil to lubricate them at pleasure, I purchased a Seibert lubricator and located it as shown in Fig. 3. A T was put in the pipe *A* at *E*, the pipe *H* was inserted and continued as shown at *I* and *J* to the lubricator. Formerly, there was an L at *F*, but it was removed and a T put in its place, so that the pipe *K* could be connected to it. The cup was filled with kerosene oil and the regulating valve partially opened, but the oil would not come out of the nozzle and ascend through the water in the sight-feed glass, as it does in the case of a lubricator attached to the steam pipe of an engine. The reason for this is as follows: There is a column of water at *J*, which, in this case, is 25 inches high, but the weight of it is balanced by 25 inches in height of the pipe *H*; therefore, there is no difference in weight to force the oil out of the sight-feed nozzle. To overcome this defect, the nipple *G* was taken out and a brass plug driven into it. A hole $\frac{3}{32}$ inch in diameter was bored through this plug, after which the nipple was replaced, and the whole device worked to perfection.

The operation of this arrangement is superior to that of an ordinary lubricator, because it only feeds when the water is passing through the pipe *D* to raise the piston in the cylinder *L*, which is the very thing required, since lubrication is needed at that time only. The philosophy of the operation of the lubricator in this case is as follows: When the steam pressure rises to the point at which it is desired to close the damper, the water valve *M* is opened and the water under pressure begins to flow through the pipe *A*. Now, if the nipple *G* provided a passage as large as the remainder of the piping, all the water would flow through it, but since it is contracted from $\frac{1}{4}$ inch to $\frac{3}{32}$ inch, the water finds an easier passage through the pipe *H*; this forces the drops of oil out of the body of the cup into the pipes *K* and *D*. If the regulating valve *N* is opened wide, the oil will flow in a stream while the damper is closing, which makes possible any slower rate of feed desirable.

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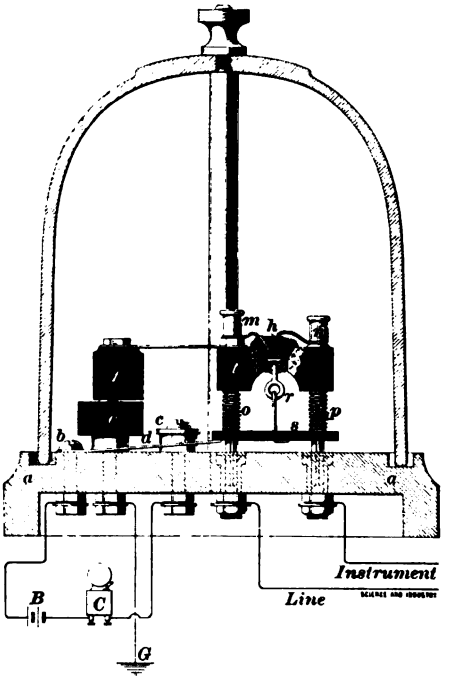
When the piston in the cylinder *L* has reached the end of its upward travel, the water is shut off, and this in turn stops the flow of oil; no more can leave the cup until the piston has descended to its lowest point and commenced another upward stroke. This makes the feed automatic after it is once properly set.

I use machine oil as a lubricant, and kerosene oil occasionally as a cleanser.

A TELEPHONE PROTECTOR

A LIGHTNING arrester and strong current interrupter, designed by Mr. C. A. Rolfe and manufactured by the Eureka Electric Company, of Chicago, has been received. A sectional view of the protector is shown in the accompanying illustration. Although the view shows only one circuit, it is a double-pole device and protects the telephone from injurious currents that may come in over either line wire. One of the important features is a small heat coil *h*, made of fine German silver wire and imbedded in an easily fusible composition; the heat coil, or *button*, as it is called, rests, as shown, in the center of a hard-rubber piece *t*. Two carbons *f* and *e* are separated only by a thin layer of a special insulating compound, and not by an air gap or by mica or silk, as is usually done. The rectangular block *e* is grounded, and a cylindrically shaped block of carbon *f* is connected by a flat German silver strip with the binding post *m* through the split brass leg or spindle *o* with one line wire binding nut. This instrument does not require auxiliary fuses in the line to protect it. It protects itself as well as the telephone.



The device operates as follows: If a lightning discharge or a current at a potential of over 2,000 volts comes in over the line, it passes through *o*, *m*, *f*, jumps across to *e*, and goes to ground *G*. From the line wire, the usual circuit is through *o*, *m*, the heat coil *h*, the binding post *n*, and the spindle *p*, to the instrument, and back through a duplicate path in the protector to the other line wire. If, from any cause, such as a cross between the telephone line wires and some power or lighting circuit, a current strong enough and of sufficient duration comes in over the line, the heat generated in the coil *h* will soften the composition and allow the springs at *o* and *p* to pull the piece *r* out of the composition, and the whole piece *t* being released will be forced up and clear out of its normal position by the strong springs at *o* and *p*, leaving a clear air gap between the line and instrument wires. The length of this gap is equal to the distance between the instrument and line binding nuts shown under the porcelain base *a a*. The line is opened at right angles to the direction of the current, to prevent the continuance of an arc across the opening, and the lightning arrester is opened, which prevents damage to the instrument itself. When this happens, the German silver spring *d* comes in contact with the metal piece *c*, thus closing a local circuit and calling attention to the fact that the telephone is cut out and that the heat coil needs to be replaced. The heat coil will operate if acted on by a current of ¼ ampere for 30 seconds, but it can be furnished for almost any reasonable capacity.

The instrument here described is a novel and useful device for the protection of telephone exchanges and subscribers' instruments from both lightning discharges and strong currents.

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PRIMITIVE PUMPING PLANTS

E. G. Van Dort

SOME METHODS OF RAISING WATER FOR IRRIGATION PURPOSES USED BY THE NATIVES OF CEYLON

THE readers of SCIENCE AND INDUSTRY, who have become so accustomed to modern methods of raising water as to think of them as being almost essentials of their every-day life, will no doubt be interested in a description of some of the methods used by people whose very existence depends

FIG. 1

on the care with which they utilize the scanty supplies of water on which the growth of their crops depends. Instead of the carefully made pump, driven by a windmill or a steam engine, a combination whose construction and operation involve a considerable amount of mechanical skill and engineering training, these primitive hydraulicians use the simplest forms of the natural products with which they are surrounded, and operate them by the muscular exertions of men or animals.

Some of the simplest conceivable devices for lifting water are those used by the natives of the island of Ceylon, for the irrigation of their "paddy" or rice fields. Paddy is a grain that requires constant irrigation during the period of its growth before the plants flower. Wherever practicable, they store the rain water in large tanks or reservoirs, so situated that the water can be drawn from them and distributed to the fields as needed. In many cases, however, small fields are so located as to make it impracticable to supply them with water from such reservoirs, and it sometimes happens that the rains fail to fill the reservoirs with a supply adequate to the needs of the crop. Under these conditions, recourse is made to some of the simple devices here shown.

In Fig. 1 is seen a very common method, remarkable chiefly on account of its extreme simplicity and the curious nature of the material of which the vessel is made. The

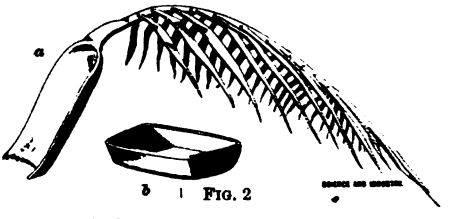

FIG. 2

stem *a* of the Areca-nut leaf (see Fig. 2) is folded into the form shown at *b*; the material is as tough as leather, but stiffer, and such a vessel lasts for years.

In Fig. 3 is shown a slightly more elaborate application of the Areca-nut leaf vessel. In this case, the vessel is larger, being made up of the stems of several leaves, and, when used in this way, the two men are able to move a greater quantity of water than they could when working with the smaller vessel of Fig. 1.

By the methods of Figs. 1 and 3, use is made of such supplies of water as are found in shallow pools, springs, or streams. When water must be lifted through greater heights, as from a well, we find our native hydraulicians making use of devices that almost reach the dignity of machines. Fig. 4, which will remind some of our readers of the well sweep that was such a familiar accompaniment of the New England farmhouse of a

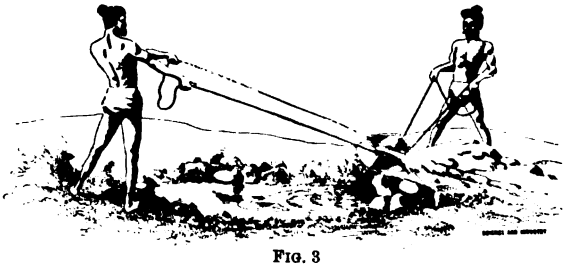

FIG. 3

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generation ago, and is still sometimes seen, is a practical application of one of the simplest machine elements and calls for little explanation. The balance weight *c* is heavy enough to nearly or quite overcome the

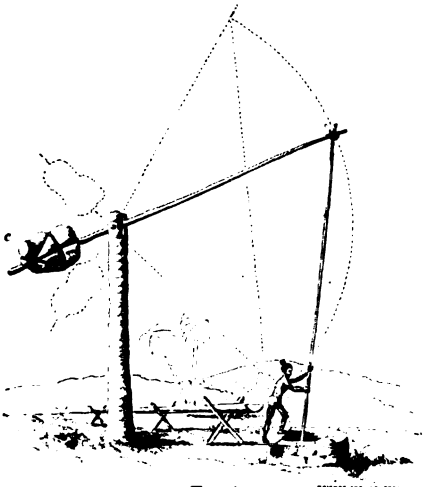

FIG. 4

downward pull of the other end of the lever, together with the bucket full of water. It thus becomes necessary, in lowering the bucket into the well, to pull downward on the long stick by which the bucket is suspended from the end of the lever, and, in raising the bucket, the upward pull is only that required to overcome the unbalanced weight, if any.

In Fig. 5 we have a somewhat more complicated application of the same principle, in which the motive power is furnished by

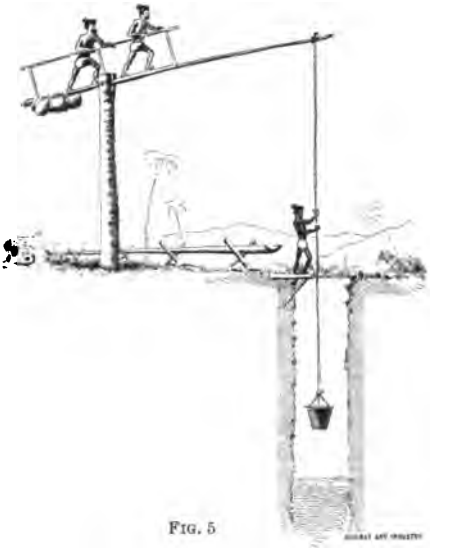

FIG. 5

bucket into the well. To raise the filled bucket, they walk toward the weighted end of the lever until enough weight is transferred to that side of the pivot to lift the bucket. The men on the top may be said to play at "seesaw," while the man on the ground, whom we may call the engineer, guides the bucket and empties it into the spout that conveys the water to the paddy field.

The device illustrated in Fig. 6 seems to represent the application of a considerable degree of inventive ability; it may, however, be the result of an accidental discovery or of a slow process of evolution. Whatever its origin, we cannot help admiring the neat way in which the materials are applied so as

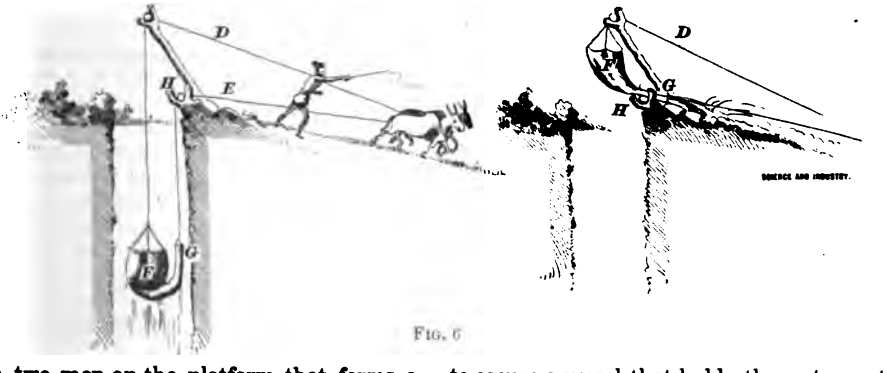

FIG. 6

the two men on the platform that forms a part of the lever. By walking toward the end of the lever from which the bucket is suspended, they overcome the effect of the weight on the other end, and lower the

to secure a vessel that holds the water until it reaches the top of the lift and then empties itself into the spout leading to the field.

The motive power is furnished by bulls trained to walk backward and forward as

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the vessel is to be lowered and raised. The vessel F is made from the whole skin of an ox, and it is provided at its lower end with a tube G, also made of leather. The vessel and tube are respectively hitched to the bulls by the ropes D and E. When the vessel reaches the top of its lift, the tube is drawn forward over the lower roller H, as shown in the right-hand view, thus permitting the water to flow out. When the pull on the ropes is relieved by the backward motion of the bulls, the weight of the vessel is sufficient to carry it back into the well; the tube takes the position shown in the left-hand view, and the vessel is ready to be filled and raised again.

SHUNT DYNAMOS IN MULTIPLE

E. C. Parham

RESIDUAL MAGNETISM—CHARGING—BUILDING UP—PICKING UP—GENERATING—ARMATURE AND FIELD LEADS—CONNECTIONS IN MULTIPLE

A DYNAMO very often called on to be run in multiple is the shunt dynamo, so named because its field circuit side tracks, or shunts, the external outside working circuit, as shown in Fig. 1. A is the dynamo's armature where the voltage is generated; F is the fine-wire shunt field; L is a lot of lamps in multiple, which represent the load in the outside circuit; K is a switch by means of which the external circuit can be cut off or opened; K_1 is also a switch by means of which the fine-wire field can be opened, and the activity of the dynamo thereby killed.

After the field of a dynamo has been once excited, the iron or steel in its frame retains a certain amount of magnetism, even after the current that caused it has been removed. The magnetism so retained is what is called the *residual* magnetism, and it is this remnant of its last *charge* that a dynamo uses to start its next building up. If the field lost all its magnetism each time it was shut down, before it could be made to work again the field would need to be given a charge. This means that the fine-wire winding F would have to be put in series with the live wires from another dynamo or from a primary or a storage battery, and a small current sent through it. This operation is called *charging*, and if it had to be done each time that a dynamo was started up there would have to be special time-saving devices installed for doing it. Fortunately, no such thing has to be done, as a rule, although dynamos do sometimes lose their fields, in which cases the fields must be charged.

As soon as the armature of Fig. 1 begins to turn, its wires begin to cut across the few lines of force provided by, or rather due to, the residual magnetism. This sets up a small voltage, or E. M. F., in the armature; as the speed increases, so does this E. M. F., and also the small current that it causes to flow through F; as this current increases, the field gets stronger, and this gives the E. M. F. another boost and enables it to send a still stronger current through F. The field current, E. M. F., and magnetism go on reacting on one another until they all reach a limit governed by the speed, field-circuit resistance, and general design of the dynamo. The field builds up very slowly at first, but after a certain point is reached it runs up very rapidly to almost the limit, and then its rate of building up slows down again. This action can be partly followed by observing the dynamo's pilot lamp, which will be seen to increase in brilliancy, very slowly at first, but more rapidly after the field has a good start.

A shunt dynamo running alone on a circuit is a very simple thing to look after; the two switches K and K_1, the main-line and field switches, need never be pulled at all—all shutting down and starting up can best be done by stopping or starting the engine or other power source that runs the dynamo. In so doing, however, if the dynamo has copper brushes, they should be lifted before the machine comes to a stop, for if the commutator is the least bit rough, the brushes are apt to be stumped on the end when the machine kicks back a little at stopping. It can be seen from Fig. 1 that if both K and K_1 are left in the current from the armature, the current will split at point o; part of it goes to the left through the field circuit, to excite the field, and part

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to the right through the main line, to light the lamps. The resistance of the field circuit is very high compared to that of the main line, so the E. M. F. of the armature can send but a small current through it, while that through the main line, up to the load limit,

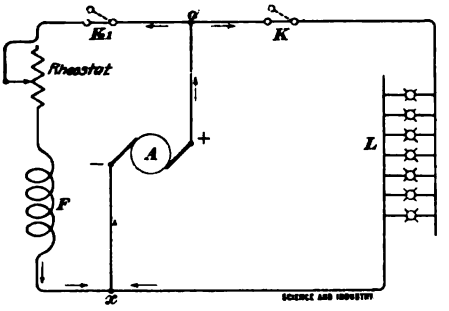

FIG. 1

depends on how many lamps are turned on. It is easy to see that since the main line and the field circuit are in multiple, the dynamo can excite its own field, even when the main-line switch is open.

Fig. 2 shows the actual connections of a shunt dynamo running alone on an isolated circuit of its own. In this figure, *A* is the armature and *F* the fine-wire field; *r*, the rheostat in series with the field; *L*, the lamp load; *P*, the pilot lamp that enables the dynamo tender to tell when the voltage is right; *H*, a wooden headboard screwed to the keeper, or yoke, of the dynamo; this board carries the three connecting blocks b_1, b_2, and b_3, and also the pilot lamp *P*. When switch *K* is closed, it connects blocks b_2 and b_3, and enables the current from the armature to flow through the main line. The pilot lamp *P* is connected as shown, the dotted connection indicating that the two wires are run behind the board where they cannot be seen. K_1 is the field switch. Opening switch K_1 kills the machine, but opening *K* does not open the field circuit, because it is connected to the lower block b_2.

If the field circuit were connected to the upper block b_3, then the opening of *K* would kill the field at the same time that it cut off the main line. In the position shown in the figure, the field rheostat has all its resistance cut in, and when so placed, a great many dynamos will not *pick up* a field, because the resistance of the field circuit is too high. To cut the rheostat out, the handle bar must be turned counter-clockwise as far as it will go. When the pilot lamp shows the field to be picking up, some of the resistance must be cut in again, because if the main-line switch is open so that there is no outside load, the voltage will run up high enough to burn out the pilot lamp. A dynamo will support its field, once established, through a much greater field-circuit resistance than it will pick up through.

Every dynamo tender knows about where the rheostat handle bar ought to rest on his own machine in order to have the pilot lamp burn at the right brilliancy. If the main-line switch is closed before the dynamo has picked up its field, it is apt to lose it again; this is especially the case if there are so many lamps turned on that the machine is overloaded, and if there is a short circuit on the main line the machine is certain to lose its field as soon as the main-line switch is closed, but it may lose its belt before it does so. If there is a short circuit in the pilot lamp, the dynamo cannot pick up its field well even with the line switch open. The popular reason given for this action is that, since the field circuit and the short circuit are in multiple, the short circuit takes all the current and leaves none for the fields; but the real reason, which holds in all cases, is that the low-resistance short circuit,

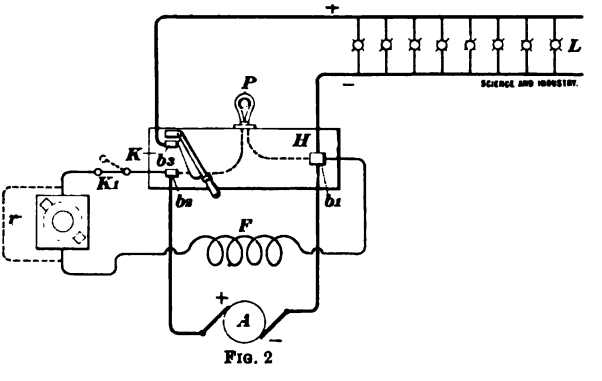

FIG. 2

being in multiple with the fields, brings down the potential, or drop, across their terminals to such a low value that it will not support a field. Another condition under which a shunt machine will fail to pick up its field is when there is a loose connection or an open circuit in its field or rheostat.

Where the dynamo is alone on the circuit,

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no serious damage can arise as the result of such a fault; but when there are two or more machines in multiple on the same line, the trouble is apt to be injurious if it occurs while they are in together. To find out whether or not the fault is in the rheostat, hold a piece of wire across its connecting posts, as shown by the dotted line in Fig. 2. To find out whether it is one of the field coils, hold it across the coils, one at a time. As soon as the wire bridges the fault, the machine will show signs of generating. A dynamo may often be made to generate by holding a piece of wire across the brush holders, thereby short-circuiting the armature. The effect is to lower the resistance through which the armature has to work, so that what residual magnetism there may be can cause a large current to flow through it. Some of the lines of force due to this current then find their way through the pole pieces and give them a start. When doing this, though, the brushes should be watched, and as soon as small sparks appear under them the short-circuiting wire should be taken away.

A machine will sometimes fail to generate because the commutator is dirty, or because the brushes make poor contact or have become burned on the ends. If the commutator is dirty, lift the brushes and use a sand block; then apply vaseline through the pores of a canvas rag. If the brushes are dirty, take them out and dip them into a can of gasoline — not kerosene, because it takes too long to dry. If the brushes are

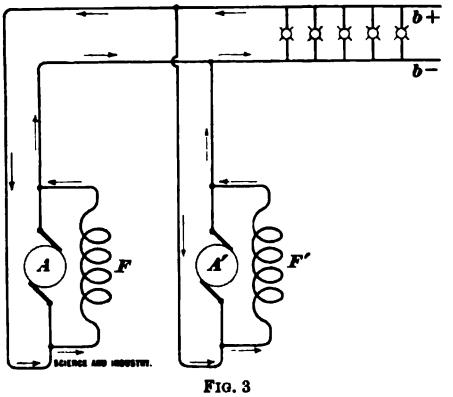

FIG. 3

burned on the ends, put them into a jig and file them down to shape; do not try to do it without a jig of some kind. If the machine still refuses to generate, it may be because the armature or field leads have been crossed, i. e., one put where the other ought to go, or the ends of the individual field coils may be reversed as a result of the leads having been brought out to the wrong lug on the coil.

For a given direction of rotation, the armature leads and the field leads have to be connected in a certain way, or the machine will not generate. Thus, in Fig. 2, if the field lead going into block b_1 is made to exchange places with the rheostat lead going into block b_2, the dynamo will refuse to generate unless either the armature leads or the direction of rotation is reversed. The reason is this: Let us suppose the dynamo to be connected right and to be generating; this means that the field current flows around the field coils in such a direction as to produce a magnetic field, which enables the armature conductors cutting this field to generate an E. M. F. that in time will reenforce the initial armature current due to the residual field.

Now, let the first terminals be reversed (for the sake of clearness we will suppose that there remains a residual field, due to the current last flowing); under this condition, the pole pieces are of the same polarity as they were when the machine was generating, since the lines of force due to the residual field are in the same direction as when the machine generated. The small current now in the armature, due to the residual field, will be in the same direction as it was then, but, the field connections being reversed, the current now flows around the field coils in such a direction as to neutralize the residual magnetism. The slight magnetizing force due to the residual field now opposes this field, and soon reduces it to zero, thus totally depriving the machine of all ability to pick up, even if it otherwise could. Nor can a reverse residual, even if established by recharging, be maintained; for, assuming a reversed residual to be provided, the lines of force having changed direction, the armature current does likewise, and previous conditions being reestablished, the residual field is destroyed again.

Fig. 3 is a diagrammatic sketch of two shunt dynamos in multiple. Fig. 4 shows the actual connections of two such dynamos. In Fig. 4, A is the armature and F the field of one dynamo; A' is the armature and F' the field of another; r and r' are the two field rheostats; K and K' are the two main-line switches; K_1 and K_1' are the two field switches. The dynamos are in multiple. When two dynamos are in multiple,

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conditions are very much changed from what they are when the two dynamos are in isolated circuits. Let us suppose that the two dynamos are run from different engines, both of which are shut down, and that it is desired to start up both machines and throw them in together on the same lamp load, some of which is shown at L, Fig. 4. The two main-line switches K and K' are open, so are the field switches K_1 and K_1'. The first thing to do is to start up one engine and get its dynamo up to speed; next, wipe off the commutator with a rough dry rag and let down the brushes. Let it be the No. 1 dynamo that is started up first; close its field switch K_1 and also its main-line switch K. The main-line switch must be closed, since, for certain reasons to be taken up later, the field-circuit wire from the rheostat is connected above the switch; no current can get from the armature to the field until this switch is closed.

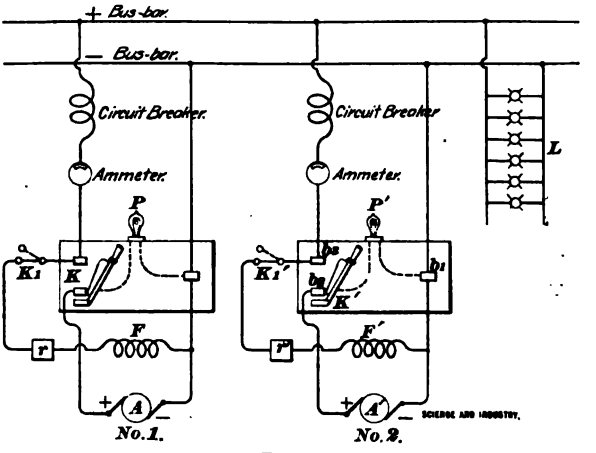

FIG. 4

As soon as the two switches are closed, cut all of the resistance out of the field rheostat and watch the pilot lamp; as soon as this lamp begins to show a good glow, cut the resistance back into the rheostat and juggle the handle bar until the pilot lamp burns at about the right brilliancy. As things are now, K and K_1 are closed and No. 1 machine carries all of the load that there is, but K' and K_1' are open and No. 2 machine is dead. If the dynamos are lighting machines, with copper brushes, it will be necessary to move the brushes forward in the direction of rotation, as the load goes on, to avoid sparking; but if the machines are up-to-date street-railway generators, with carbon brushes, it will not be necessary to move the brushes at all.

Let us suppose that the fast-increasing load calls for the second machine at once. The problem is to get it into service without a demonstration of any kind. The first thing to do is to start up its engine and lower its brushes. This done, close field switch K_1'. Since the field is connected in above the main-line switch, as soon as the field switch is closed on No. 2 dynamo, its field takes a current from the bus-bars fed by No. 1 dynamo. This insures that if No. 2 field connections are right, No. 2 armature will generate an E. M. F. of such a polarity that the two machines will be in multiple and not in series. The next thing to do is to bring the voltage on No. 2 machine up to the same value as that on the line. This can be done by means of two incandescent lamps, each of which can stand the full line voltage, connected in series, and provided with long leads to be used as test leads. (On street-railway circuits, it is customary to use a voltmeter, but ten lamps in series can be used.) The pressure on the line can be found by looking at the pilot lamp on No. 1 dynamo. The rheostat on the No. 2 machine must be adjusted until its pilot lamp burns at the same or a little greater brilliancy than that on the No. 1.

On the No. 2 dynamo's headboard the conditions now are these: Between blocks b_1 and b_3 is the voltage of the line; between blocks b_1 and b_2 is the voltage of the No. 2 dynamo. These two voltages are the same, and they ought to be in opposition; if they are, the two test lamps, when held across the jaws of the switch, will show no light at all; but, if the two voltages do not oppose, the No. 2 dynamo and the line are in series, and both test lamps will light up to full candlepower. In such a case, the field connections on No. 2 machine would have to be reversed. Should the main-line switch on No. 2 machine be closed when No. 2's polarity is wrong, there would be a dead short circuit through the two dynamos in series, and one or both of the belts would go off, unless the circuit breaker acted in time. If the test lamps show no glow, bring up the voltage on No. 2 a little

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and close switch K'. To make No. 2 take its share of the load, more resistance must be cut out of its field rheostat as No. 2 takes more load; some of this load will work off No. 1, and in order to have each machine take the right part of the load, both rheostats must be adjusted after the brushes are rocked to the non-sparking point, and it will be necessary to keep an eye on the two machines as the outside load varies, both to keep the voltage right and the loads shared proportionally.

To take a machine out of service, resistance must be cut into its rheostat until the ammeter goes down to almost zero, when the main-line switch can be safely pulled without burning. If the No. 1 and No. 2 field rheostats are close together, the load can be worked on to one machine at the same rate that it is worked off its mate.

COURTESIES IN LETTER WRITING

Frances B. Callaway

A GOOD quality of paper, black ink, and clear handwriting are courtesies in letter writing that show consideration for one's correspondent. Special pains should be taken to make the signature plain and legible, as a business correspondent, whose time has money value, cannot afford to spend an hour in deciphering an illegible wriggle. Care should be taken also to address the envelope in a plain hand, giving particular attention to the state, as abbreviations like Col. and Cal. look very nearly alike.

It is a courtesy to the postal service to place the stamp in the upper right-hand corner, where it belongs, as the work of canceling must often be done with lightning-like speed, and it is awkward to shift the letter about. The post-office authorities have recently announced that they cannot be held responsible for the safety of letters when the stamp is out of place.

Over one million dollars in money, checks, and drafts was received at the dead-letter office last year. This delay, confusion, and even loss might have been avoided if the return address had been written on the envelope. Of the six million pieces of mail matter received at the dead-letter office, a great proportion was due to carelessness and illegible handwriting.

A letter usually contains some questions that it is friendly and courteous to answer, for letters, like conversation, are made up largely of questions and answers. In asking questions of strangers, a stamped and addressed envelope should always be sent, as there is no reason why an editor or other business man should expend his income in buying stamps and envelopes for the benefit of some one else. In these letters of inquiry, one should be considerate and not ask foolish questions, or questions that it would take an encyclopedia to answer. An interrogation point is not a comfortable correspondent, particularly when there is no point to the interrogation.

An author received the following letter from an entire stranger, with neither stamp nor envelope enclosed:

> I enjoyed reading your article so much. Can you tell me about all the machines used, and also what you mean by a jig pin? Thanking you in advance for the favor, I am,
>
> Gratefully yours,
>
> _____.

The publisher forwarded this letter to the author, who, in turn, answered the correspondent, the cost being four cents, besides the time and stationery. This paper has half a million readers. If every one sent in such letters of inquiry very often, both paper and author would go into bankruptcy.

Any evidence of haste, such as "Dr. Sir" and "Yrs. rsply." convey an unpleasant impression of rudeness, and "I remain" is considered rather ridiculous. It is more courteous to begin with "My dear Sir" or "My dear Madam" and close with such gentle words as "I am, Yours truly," "Yours faithfully," or "Cordially yours."

Politeness in letter writing, as in conversation, comes from an unselfish heart, and, as some one has defined it, "is true kindness beautifully expressed."

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HEATING FRAME HOUSES BY WARM AIR

M. L. King

INSTALLATION OF A FURNACE—VELOCITY AND TEMPERATURE OF AIR IN STACK—PROPORTIONS OF GRATE AND HEATING SURFACE

THE warm-air furnace has suffered considerable neglect at the hands of heating men, and, while much has been done to elevate it to a position to which we believe it belongs, we may even now see new furnace plants placed with no more regard for natural laws than was displayed fifty years ago.

Let us glance at the conditions to be met in the ordinary frame dwelling. We have a space subdivided into rooms and surrounded by walls of more or less non-conductivity. These walls are broken at many points for doors and windows. Little or no attempt is made to make the window spaces non-conductors, and as doors and windows are necessarily easily movable, the joints and edges allow ingress and egress to large quantities of air. There are many other leaks, or unintentional air passages, in the outer walls, however, as any one may readily find by placing the hand at the floor and base line on the windward side of the house. It is desired to heat the space thus enclosed to a temperature of 70° in zero weather, by conveying air at a much higher temperature to these rooms. This heated air mixes with the air in the room, and, after losing some of its heat by contact with the cooler air and with walls and windows, it escapes at a temperature of 70° through these cracks and crevices. As the ordinary frame dwelling is not provided with special ventilating ducts, these air leaks are really blessings in disguise. Special ventilating ducts and open fireplaces are coming into more general use, however, and are desirable adjuncts to a furnace-heating plant.

The larger number of houses heated by warm air are still unprovided with these ducts, and in the present article they will be ignored. The only reason why a furnace will heat a building that has no outlet flues or open fireplaces, is because air *does* escape from the building in large volumes, which may be easily demonstrated by measuring the air that enters the fresh-air duct and passes through the furnace. No two bodies can occupy the same space at the same time; therefore, an entering volume of fresh air must displace an equal volume of air already in the house.

The installation of a well-planned furnace job should begin with the construction of the house. The furnace man should call the attention of the architect or house owner to the fact that, as ordinarily constructed, the spaces between the studding, or furring, will act as a series of flues unless they are closed at each floor and ceiling. If this is done, the spaces are dead air spaces, and therefore good non-conductors. If it is *not* done, there will be a constant upward draft between the studding, from cellar to attic, and under the floors between the joists. The writer has seen a poorly constructed house in which the flooring of a room was so badly shrunken that when the wind blew in certain directions the carpet would rise in the center, from wind pressure. A house like this has no chance to escape utter destruction in case of fire. The furnace man should also recommend the laying of a thickness of felting or the specially prepared non-conducting building paper on the wood sheathing under the siding. Let it be borne in mind that we are not trying to make our dwelling *air-proof*, but more nearly *cold-proof*.

An important part of the work is to sketch out a plan with cold-air ducts, warm-air stacks and pipes, registers, and, above all, a furnace properly proportioned and *large enough*. The sketch should be drawn to scale, and have measurements written on the several parts.

The writer has seen many stacks $3\frac{3}{4}$ in. $\times$ 12 in. connected to 11-inch pipes in the cellar, and registers 10 in. $\times$ 14 in. in the parlor walls. The capacities by this arrangement will be as follows: Pipe in cellar, 95 square inches; register, 93 square inches; stack, 45 square inches. The man that places such a combination will tell you that the air in the stack travels twice as fast as the air in the cellar pipe. This is, in a measure, true, but it would be better expressed by saying that the air in the cellar pipe travels half as fast as the air in the stack. A chain is never stronger than its weakest link. It is just as true that the capacity of a pipe is no greater than the

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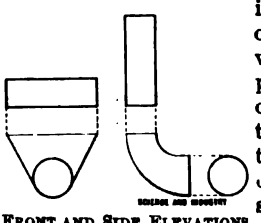
capacity at its smallest part. The cellar pipe may, however, have 25 per cent. greater capacity than the stack to which it is connected.

There are rigid natural laws governing the movement and velocities of warm air in flues, and in order to attain a velocity of 5½ feet per second in the ordinary stack to the second floor, the temperature of the air in the stack must be about 170°. To increase the velocity 1 foot per second requires an increase of temperature of about 35°. From the foregoing, it will be seen that to maintain a good-sized room at a temperature of 70° in zero weather, with a stack 3¾ in. × 12 in., requires a high velocity, and, therefore, a high temperature. This is not healthful to the occupants of the house, and is hard on the furnace and coal bin. The aim should be to provide large volumes of air at low temperatures, and the stacks should therefore be of IX bright tin, 5½ in. × 8, 10, or 12 in., according to the exposure, cubic contents, and use of the room.



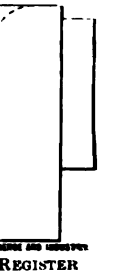
FRONT AND SIDE ELEVATIONS OF ELBOW BOOT

CURVED STACK ELBOW

The foot-piece of the stack, or the "boot," may be made of one section of rectangular stack, rounded and tapered at the bottom to fit the cellar pipe. An ordinary elbow can then be run into the bottom of the boot, and pointed directly toward the furnace collar. Where stacks start over a girder, the same kind of rounded taper piece may be used, except that it is made part of the 45° elbow. Where the stack starts on top of a stone or brick wall, the boot piece should be made in the form of an elbow, having its upper end rectangular, to fit the stack, and its lower end round, to fit the cellar pipe, or "leader."

EFFECTIVE AREA OF RECTANGULAR PIPE

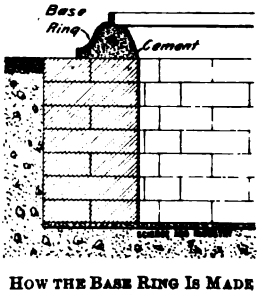
All elbows in the rectangular stacks should be curved, and the top of all register boxes should be curved in the same manner. The same results may be obtained by using ordinary square stack elbows, and soldering a curved piece of tin across the angle. As the stack is being made, each piece should be marked on the inside with soap, and, when all are made, the apprentice may take the paste pail and brush and cover the stacks with asbestos sheathing, taking care to leave uncovered the joints that are to be soldered when they are placed in position. A few drops of oil of cloves will prevent the paste from souring. After the paste has dried, mark the explanatory directions with blue pencil on the asbestos of each piece.



REGISTER HEAD

Nothwithstanding all that has been said and written in favor of oval stacks, the writer is convinced that a rectangular stack is more efficient than an oval stack of the same dimensions, and is easier to make. The corners of a rectangular pipe are undoubtedly occupied, to some extent, by sluggish air; but the friction encountered by the rising column of warm air in passing or rubbing against the sluggish air is certainly less than the friction encountered by the air rubbing against the ordinary tin stack. In other words, rolling friction retards less than sliding friction.

After the roof is on and the floors are laid, the work in the cellar may be commenced, and this leads us to the choice of a furnace. This should be well made and heavy, with easy air passages, and smoke-flue travel as short as is consistent with the proper exposure of a large amount of heating surface. It should have a proportion of grate to heating surface of at least 1 to 40 or 45. Every furnace manufacturer claims that his furnace "contains more heating surface than any other furnace made." The question will occur: If a large proportion of heating surface to grate surface is so desirable, why do not furnace manufacturers make them so? The answer is that they would require too much flue travel. Furnaces are made to sell, and they will not sell unless they can be made to work with the average chimney. It would be comparatively easy to so place the flues in a furnace that the gases would be compelled to travel around the circumference of the furnace five or six times. This would furnish large heating



HOW THE BASE RING IS MADE AIR-TIGHT

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surfaces, but the chimney draft would need to be supplemented by a small fan. There are, however, furnaces made according to the requirements mentioned above, and with not more than 8 feet of flue travel in the larger sizes.

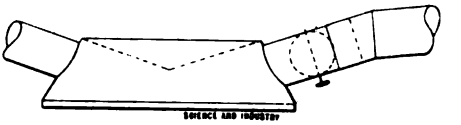
The writer recalls a form of furnace put on the market a few years ago, in which the gases traveled around the usual cast-iron radiator, after leaving the combustion chamber, and then passed down and through an additional radiator near the base of the furnace. This was gradually superseded by a pattern having but one radiator. With the two radiators, there was 24 feet of horizontal flue travel before leaving the furnace.

Care should be taken to have the total area of the air passages through the furnace equal or exceed the total area of the leaders

A GALVANIZED FRESH-AIR DUCT

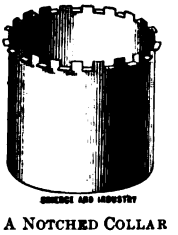
from the furnace. This feature of the furnace job is liable to be overlooked. The area of the fresh-air duct should equal at least three-fourths the area of the combined hot-air pipes. The underground duct and furnace pit should be from 14 to 24 inches deep, according to the size of the house, and should be as wide as the product of the depth and width of the required area. This underground duct should be built up with 8-inch hard-burned brick, laid in cement mortar and covered with flagstone, which should be laid in cement and level with the cellar bottom. The bottom of the duct should also be grouted with cement. This duct should extend to a cellar window in the west or north wall, and the furnace pit should preferably be located a little to the northwest of the center of the cellar, in order to favor the pipes on that side. In the center of the furnace pit should be built a brick pier 12 or 16 inches square, with one edge of the pier pointing toward the entering fresh air.

A galvanized fresh-air duct from the



FURNACE HOOD, SHOWING DAMPER IN THE COLLAR

fresh-air opening in the wall to the underground duct is cheaper than wood, and more sanitary and durable. The sash and glass that were intended for that opening may be placed in the inner end of the galvanized tube, and thus no light need be sacrificed. The sash should be placed with the putty side facing the cellar, so that in case of breakage the sash may be easily reglazed. In the front side of the galvanized duct, and about 2 feet from the cellar floor, there should be a manhole covered by a door that should swing inwards and be provided with a notched lever that will allow it to be set at any desired angle. This door allows the outside air to be shut off, either entirely or in part, but does not affect the air supply to the furnace, because the cellar manhole will be opened in the same proportion as the outside air supply is closed. This manhole damper also permits of cleaning out the underground duct, and has the advantage of showing the position of the damper at a glance. A tight damper in the duct should not be tolerated under any circumstances. Furnaces, like men, must have a constant supply of air. It is questionable whether dry cellar air sent through the furnace and up into the house is worse than the overheated, ill-smelling air that is conveyed by back-siphoning through the nearby registers to feed those of the second floor.



A NOTCHED COLLAR

The galvanized duct should be well stiffened with angle bars at the bottom, and carefully cemented to the brick duct. A galvanized screen of ¼-inch mesh should be fastened in the fresh-air opening in the cellar wall, to exclude animals and large insects. Both the manhole opening and the swinging door should be stiffened with ¼-inch or ⅜-inch rod, according to the size of the opening.

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When the base plate, or ash-pit bottom, is set on the wall of the furnace pit, it should be carefully leveled, and good stone or slate wedges cemented between the center pillar and the base plate. The base ring should then be filled with cement and pieces of brick or stone, care being taken to reach down under the ring at the point where the ash-pit door is placed. Careless work here will allow ash dust to escape into the duct and up through the house by way of the registers.

Since one form of furnace hood would not answer for all cases, many forms are made, but the one best adapted for general use is that in the shape of a frustum of a cone, with an inverted cone riveted on the inside. This permits each pipe to gather warm air from a large area. The collars should be set in the sides of the hood at the same angle as the inverted cone, and the warm-air pipes continued at the same angle to a height sufficient for headroom. From thence to the boot pieces the pipes should have all the grade possible. Each pipe should have a damper, as it is difficult to place the collars so that each pipe will draw evenly at all times, unless the dampers are adjusted for each register to get an even "pull" on the furnace. The dampers should be placed in the galvanized collars, close to the furnace. This allows any pipe to be taken down while fire is in the furnace by merely turning off the damper in the collar. More space should be allowed on the hood for the longer pipes, which are those leading toward the north and west, than for the shorter or less favored ones. No collar should be placed in the space directly over the feed-door, as that has little heat value. An asbestos air-cell covering, pasted on hood, collars, and pipes, makes a good job. A single thickness of asbestos sheathing pasted on is not so good, but is many times better than no covering at all.

A quick and neat method of fastening in the galvanized collars is to set the collar up against the hood in the proper position, and mark around the collar on the hood with a lead pencil. With curved snips, cut the circle thus marked and place the collar in the hole, pointing in the proper direction, and make sure that it entirely fills the hole in the hood. Then mark around the collar *against the hood*, and place indicating marks on both collar and hood, so that the collar may be replaced exactly as it was marked. Take out the collar and cut it on the line, and at ¾-inch intervals make notches about ¾ inch deep. Turn every other nib outward with the pliers, and place the collar in the hood and flatten back the remaining nibs. When it is desired to set the collar on a tangent with the hood, the hole in the hood must be cut oval instead of round.

If the smoke pipe is long, it should be covered with a thickness of asbestos. This will materially aid a faulty draft, as it allows the gases to retain their heat longer, and closes up any small leakages at the joints.

EFFECT OF ICE WATER

MANY people wonder why it is that their physicians advise them not to drink water during meal time. The fact of the matter is that persons are not harmed by the water if it is taken at an ordinary temperature; but most Americans are not satisfied with this—they think they must have ice water. In order to carry on digestion properly, a certain temperature is necessary. The temperature of the stomach varies from 98° to 100° F. After a meal, the temperature increases until it is sometimes 102°, while if the circulation is quickened by exercise, the temperature will be still higher.

Now, the effect of ice water on the digestion is very apparent. By continually drinking this water during a meal, or indulging in an ice for dessert, the temperature of the stomach will sometimes be reduced to 95°. This would stop digestion and eventually lay the foundation for such a disease as dyspepsia. Since foods are easily digested when they are partially diluted, it is well to take a drink of water occasionally during a meal, but the water should not be iced.

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THE ECONOMIC COMBUSTION OF COAL

C. P. Turner

SOME PROPERTIES OF COAL—COMBUSTION OF VOLATILE SUBSTANCES—COMBUSTION OF FIXED CARBON—SMOKE PREVENTION—PROCESSES THAT ABSORB HEAT

SINCE fuel, chiefly in the form of coal, is the source of all the energy made available by the steam engine, a study of the principles governing the economical generation of power by means of the steam engine must begin with a study of the combustion of fuel and the means of preventing a waste of heat by guarding against those conditions that make combustion incomplete. Heat lost by imperfect combustion cannot be recovered by any means; no arrangement of elaborate and economical machinery in the engine room will utilize the energy wasted in the fireroom through ignorance or carelessness on the part of the fireman. Furthermore, one of the most serious problems confronting the steam engineer is the burning of soft coal without the formation of black smoke, and this problem depends for its solution more on intelligent work in the fireroom, which involves a knowledge of economic combustion, than on patented furnaces.

Bituminous coal is composed largely of various compounds of carbon and hydrogen called *hydrocarbons*. When the coal is heated, these compounds are driven off partly in the form of permanent gases and partly as vapors that may easily be condensed or changed to a liquid form. The process of separating the gases and vapors from the part of the coal that cannot be vaporized by the mere action of heat, is called *distillation;* the substances driven off from the coal by heat are volatile substances, and the portion remaining forms *coke*, which is composed chiefly of carbon. This carbon is called the *fixed carbon* of the coal.

The volatile substances may be divided into two classes, viz., non-combustible and combustible substances. The first class consists mostly of water, free oxygen, and nitrogen; these are driven off when the coal is heated—the water as steam and the gases in a free state. The second class consists of hydrocarbons, which comprise numerous compounds of hydrogen and carbon. When the coal is heated, part of the hydrocarbons are driven off in a gaseous form and part as vapors. The principal gases in the volatile combustible are carbureted hydrogen, or marsh gas, consisting of 1 atom of carbon and 4 atoms of hydrogen, as shown by its symbol CH_4, and olefiant gas C_2H_4. With many coals, free hydrogen is given off in considerable quantities; small quantities of other less important gases are also generally present.

The vapors are mostly coal tar and naphtha, with small quantities of sulphur. Their presence can be detected by placing a cold iron bar in the yellow gases rising from a fresh charge; a sticky coating, consisting mostly of condensed tar, will form on the cold metal.

The proportion of volatile matter in coal depends on its composition. Anthracite consists almost entirely of fixed carbon and ash; while in some bituminous coals the greater part is volatile matter. The relative proportions of fixed gases and condensable vapors in the volatile parts of coal also vary with the composition of coal. In some cases, the volatile matter contains considerable quantities of the tarry vapors and heavy hydrocarbon gases, as C_2H_4, while in others it consists largely of the light marsh gas CH_4 and free hydrogen.

The quantity and composition of the volatile matter depends not only on the composition of the coal itself but also on the conditions under which distillation takes place, a difference in the temperature and the presence or absence of air or steam modifying the composition of the vapor and gases to a very great extent. Irregular firing and draft result in a great difference in the quantity and composition of the gas to be burned in the furnace at different periods.

With few exceptions, coal contains small quantities of sulphur, usually in combination with some other element; one of the most common compounds is that of sulphur and iron, known as *iron pyrites*. When the coal is heated, the sulphur is separated from the iron and burns to sulphur dioxide SO_2. The heat derived from the combustion of the sulphur found in coal is small, but the sulphur dioxide formed, in combination with the moisture in the gases, corrodes iron very rapidly; any relatively cold metal

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exposed to the gases from coal rich in sulphur is rapidly corroded and destroyed.

At the temperature generally existing in a boiler furnace, the tar and other liquids are vaporized and mix with the gases. This gaseous mixture is readily burned under proper conditions of air supply and temperature. The conditions involved in the combustion of the gases and vapors may readily be studied by the aid of the flame of a common tallow candle. The tallow forms a supply of solid hydrocarbon, which, under the action of the heat of the flame, is liquefied; then, by capillary attraction, it is drawn up into the wick to a point where the heat is sufficient to vaporize it. A process of distillation here goes on, and a blue, transparent, cone-shaped mass of vapor and gas, shown at *c*, Fig. 1, is formed. The heat of the flame causes a current of air to approach from all sides, and provides a supply of oxygen that comes in contact with the surface of the hot cone of vapor. The air that reaches this part of the flame, however, is not sufficient for the complete combustion of the vapor; and, since the hydrogen in the hot cone has a greater affinity for oxygen than it has for carbon, it combines with all the available oxygen and burns to water H_2O. The carbon is left in the form of minute solid particles that become highly heated and give this part of the flame its bright-yellow color. As the hot particles of carbon rise, they come in contact with the inward current of air, which furnishes oxygen sufficient to burn them to CO_2. The gas so produced, mixed with the H_2O from the luminous portion *b* of the flame, forms the nearly colorless outer and upper section *a*, which gradually mixes with the surrounding air, cools, and becomes wholly invisible.

FIG. 1

If we insert the end of a glass tube into the inner cone of the flame, as shown in Fig. 2, a part of the gas which has as yet not received a supply of air may be drawn off. In passing through the tube this gas is cooled below the temperature at which it will burn, and it issues from the tube into the air without igniting. By applying a lighted match to this gas and heating it, it may be lighted and burned. This simple experiment illustrates two of the most important principles involved in the economical combustion of the gases in a boiler furnace. It shows, *first*, that gas that has been cooled below the temperature of ignition cannot be burned merely by furnishing a supply of air; *second*, that when the gas is supplied with air it can be burned if its temperature is raised to the igniting point.

In order to burn the fixed carbon in the coal, a high temperature is needed to cause the atoms of carbon to combine with the oxygen supplied by the air. The igniting temperature of the fixed carbon, and also of the volatile substances, is estimated to be about 1,800° F. Since the maximum temperature in the furnace rarely exceeds 2,500° F., and is ordinarily several hundred degrees less, it is seen that, on account of the relatively small difference between the igniting temperatures of the carbon and gases and the maximum temperature in the furnace, constant care is needed to prevent the temperature in the furnace from falling below 1,800° F. The temperature in the furnace can be judged quite accurately by the appearance or color of the fire in accordance with the relation between color and temperature given in the accompanying table:

Temperature in Degrees Fahrenheit.	Appearance.	Temperature in Degrees Fahrenheit.	Appearance.
980°	Red—just visible.	2 010°	Dull orange.
1,290°	Dull red.	2,190°	Bright orange.
1,470°	Dull cherry red.	2,370°	White heat.
1,657°	Full cherry red.	2,550°	White welding heat.
1,830°	Bright red.	2,740°	White dazzling heat.

When the supply of air is sufficient and the temperature high enough, the carbon burns to carbon dioxide CO_2, which, being the product of complete combustion, is incombustible. With a high temperature and deficient air supply, carbon monoxide CO is formed. Since this gas is the product of incomplete combustion, it can be burned to CO_2 by bringing it into intimate contact with air while highly heated.

When solid carbon burns on a grate, the

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chemical changes or reactions are about as follows: Some of the oxygen of the air that rises through the grate combines with the first layers of hot carbon in the proportion of 2 atoms of oxygen to 1 atom of carbon, and carbon dioxide CO_2 is formed. As the gases rise through the fire, more of the oxygen combines with carbon, and, as long as the supply of air is sufficient and well distributed, the combination is mostly in the proportion that produces CO_2. With a thick bed of fuel, however, or an arrangement of the fuel that does not permit of a proper distribution of air, there will be some portions of the fire in which the supply of oxygen is not great enough to furnish the 2 atoms for the production of CO_2. Only 1 atom of oxygen will be available for combination with some of the carbon atoms burned, and the product will be *CO*. Further, when a molecule of CO_2 comes into close contact with the hot carbon, the attraction of the carbon for oxygen is so great that 1 atom of the oxygen leaves the CO_2 and combines with an atom of carbon; 2 molecules of *CO* are thus formed, one by the separation of one of the oxygen atoms from the molecules of CO_2, and the other by the combination of an atom of carbon with the oxygen atom so released. To separate a given weight of CO_2 into *CO* and *O* absorbs as much heat as was developed when the *CO* combined with oxygen to form the CO_2; the net production of heat is the same whether a certain amount of carbon is burned to *CO* directly and passes off in that form, or whether a part of it is first burned to CO_2, and this gas is then decomposed with the production of *CO* and oxygen, which combines with the remainder of the carbon to form *CO*. The carbon monoxide formed in the fuel bed passes on to the furnace, and if there is not sufficient oxygen present, or if the temperature is not high enough, it will pass away unburned. If sufficient oxygen is present and the furnace temperature is high enough, each molecule of *CO* will combine with another atom of oxygen, and thus burn to CO_2.

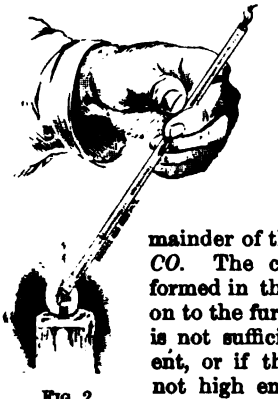

FIG. 2

A careful study of the above outlines of the processes involved shows that economical combustion, both of the volatile matter and of the solid carbon, involves the following essential conditions: (1) There must be a supply of air sufficient to furnish the oxygen required for complete combustion. (2) This air must be so distributed as to bring the oxygen into intimate contact with all parts of the fuel. (3) The temperature must be high enough to bring about the combustion. With either of these essentials lacking, there will be incomplete combustion and a loss of heat.

The smoke arising from an ordinary fire may properly be divided into two classes: *First*, the partly condensed tarry vapors produced by the distillation of the fuel; *second*, the minute particles of solid carbon left when the hydrocarbons are but partially burned. Smoke of the second class is so objectionable that in many cities there are special ordinances that either prohibit the burning of soft coal or require it to be burned in such manner that there is no formation of smoke.

When hydrocarbons are heated in the presence of air, the affinity of the hydrogen for oxygen is great enough to cause it to separate from the carbon and combine with the oxygen. If the supply of air is sufficient and the temperature is great enough, the carbon so set free will burn, and no smoke will be produced. If, however, there is a limited air supply, or a temperature too low for their combination with oxygen, the carbon atoms will combine with one another and form molecules of carbon that collect into minute particles of solid carbon. It is the presence of these hot carbon particles that gives color to the flame of an ordinary lamp or fire. If they can be supplied with oxygen at a high enough temperature they will burn, as we saw in the flame of the candle, Fig. 1. Under unfavorable conditions, however, these solid particles of carbon do not burn, but are deposited as soot or carried out of the furnace with the gases as smoke. The nature of these unfavorable conditions can well be studied by considering the action of an ordinary kerosene lamp. With a good chimney, a flame not too high, and a clean burner, the lamp burns with a bright steady flame and no smoke. The bright flame indicates a high temperature, and the absence of smoke shows that the air supply is ample and well distributed. Insert a cold iron rod into the flame from the top of the chimney; a deposit of soot—unburned carbon—collects on the rod and the gas that rises along the sides of the rod is cooled so much that a

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part of the carbon is not burned, and considerable smoke is formed. Interfere with the air supply by partly closing the top of the chimney or the holes in the burner, and a cloud of smoke is formed. Remove the chimney so as to interfere with the distribution of the air to the lower part of the flame, while a large volume of cold air meets the upper part, and we have a case in which the carbon is cooled by the action of an excessive supply of cold air imperfectly distributed. Turn the wick too high and there is more gas formed than can be supplied with air before it gets too cold for the carbon to burn.

It is seldom that the supply of air to a boiler furnace is not great enough to burn the carbon and prevent the formation of smoke; in fact, it is often found that large volumes of smoke are accompanied by a liberal supply of oxygen. The more common condition when smoke is formed is a too low temperature of the fire itself or a poor distribution of the air, which prevents oxygen from reaching the carbon before it is cooled by contact with the boiler plates. Heavy firing, by means of which large volumes of gas are formed and the furnace greatly cooled, is one of the most prolific causes of smoke production. Owing to the high ignition temperature of solid carbon, smoke when once formed is extremely difficult to burn. With properly constructed furnaces, good draft, and careful management, *smoke prevention* is possible; *smoke consumption*, however, may be said to be a practical impossibility under any of the conditions existing in the furnace of a steam boiler.

If the bed of burning fuel is thick and the draft sluggish, carbon monoxide will rise from the surface of the fire, and, if it is not burned to carbon dioxide by mingling with air admitted above the fire, will pass out through the flues and cause a great loss of heat—about 10,100 B. T. U. for each pound of carbon.

Two remedies for this type of loss are available. *First*, the fuel bed may be made so thin that sufficient air may enter through the grate to either prevent the formation of carbon monoxide or to burn it to carbon dioxide as soon as it formed; *second*, sufficient air to burn the carbon monoxide that rises from the coal may be admitted into the furnace above the fire. If there is a brisk fire and a high temperature in the furnace, the carbon monoxide can be easily burned by either of the two methods given, a short palish-blue flame being produced near the surface of the fuel. With a slow, dull fire, the temperature in the furnace may be too low to ignite the escaping gas, which will pass out with any air that may be present, no combination taking place. There is thus a double loss—heat is wasted not only by the escape of carbon monoxide but also by the heating of the excess of air.

The presence of unconsumed carbon monoxide is not easily detected by mere observation, owing to the gas being colorless. By regulating the fire, however, so that a high temperature is maintained in the furnace, and watching the surface of the burning fuel to see that sufficient air is present to produce the palish-blue flame previously mentioned, we can make reasonably sure that the amount of unconsumed carbon monoxide will be exceedingly small.

With a large grate and a very low rate of combustion, there is usually considerable formation of unconsumed *CO*, owing to the relatively low temperature in the furnace. The remedy is to restrict the grate area by bricking up with one or more courses of firebrick, so as to secure a higher combustion rate and consequent high temperature. Simply admitting more air, when there is a very low rate of combustion, is liable to increase the heat losses, since it will result in still further lowering the temperature of the furnace.

The escape of unconsumed hydrocarbon, with its attendant loss of heat, is more readily detected by direct observation of the fire than is that of carbon monoxide, especially when the loss from this source is large. The yellowish vapors that rise from freshly fired coal are familiar to all firemen, and are an evidence of unconsumed hydrocarbons. When the heavier hydrocarbons are contained in the smoke in considerable quantities, the smoke from the chimney is yellowish in color and has a tarry odor. The conditions required for the complete combustion of the hydrocarbons are the same as for the fixed carbon of the fuel; that is, a sufficient air supply, an intimate mixture of the air with the gases, and a high temperature. In practice, it seldom happens that a large part of the carbon in the volatile matter escapes unburned, even when a great deal of black smoke is produced. Owing to its finely divided state, a small quantity of carbon will give a high color to a large volume of gas coming from a chimney, and there will appear to be a serious waste when the actual heat loss is really comparatively small.

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Numerous careful tests have shown that the production of black smoke does not necessarily represent a great loss of efficiency. In many cases it has even been found that a reduction of efficiency accompanied the use of furnace arrangements that were successful in preventing smoke. The reason for this appears to be that the gases were burned with a large excess of air, which, while so controlled as to burn the carbon to CO or CO_2, thus rendering it invisible, carried much more heat from the furnace than was developed by the comparatively small weight of carbon that would have appeared in the smoke. The losses due to solid carbon falling into the ash-pit, the escape of unburned hydrocarbons, incomplete combustion of the fixed carbon on the grate, and a needless excess of air are always much more serious than the loss due to the formation of black smoke.

Although smoke in itself represents no serious loss of heat, its production in large quantities is often the result of conditions that produce imperfect combustion of the carbon monoxide and the hydrocarbons. A low furnace temperature, the piling of coal on the fire in such large quantities that an excessive volume of combustible gas is given off, while at the same time the furnace temperature is lowered by the heat absorbed in the process of distilling the volatile matter from the freshly fired coal, and also the admission of large volumes of cold air, tend to produce black smoke, and besides represent serious and unnecessary heat losses.

There are processes accompanying the combustion of coal in the boiler furnace which in themselves absorb great quantities of heat, and in consequence have an important bearing on the question of complete and economical combustion. All moisture that enters the furnace with the fuel must be evaporated at the expense of the heat developed by the combustion of the coal; the vapor thus formed passes out of the chimney at a temperature seldom less than 400°. Assuming that the moisture enters the furnace at a temperature of 70° and leaves at 400°, nearly 1,200 B. T. U. will be lost for each pound of moisture in the coal.

Moisture in coal can only be driven off by heating it above ordinary temperatures, but it will be readily absorbed at ordinary temperatures; hence it is important that coal should not be exposed to rain, but should always be stored under cover. In some cases it may be advantageous to wet bituminous coal; when wet, especially if the coal is fine, it cokes better and there is thus less waste from coal falling into the ash-pit. Wetting is only recommended for bituminous slack and anthracite culm, and should be as moderate as will secure the results desired. It would be much better, however, where the draft is moderate, to use grates with smaller openings. When the draft is exceptionally strong and very fine coal is burned, wetting becomes almost a necessity. If not done, the strong draft will actually carry a large percentage of the fine coal up the stack.

The distillation of the volatile matter is a process that, with all bituminous coals, and to a lesser degree with anthracite, absorbs a great deal of heat. The effect of this heat absorption is clearly shown by the drop in the steam pressure when a large quantity of fresh coal is thrown on the fire, which drop is largely due to the lowering of the furnace temperature through the heat absorbed by the distillation of the volatile matter. While the absorption of heat is necessary to the driving off of the volatile combustible, the losses attendant to a lowering of the furnace temperature can be minimized by frequent light charges of coal.

SUBMARINE CABLES AND ELECTRIC RAILWAYS

IT WOULD hardly seem possible that street railways would interfere with the working of submarine cables, but such is the case. The Telegraph Cable Company has brought suit against the Cape Town Traction Company for disturbances caused by the current wandering off from its track return. These stray currents affect the cable signals so that at times they are almost unintelligible. The exact way in which these disturbances are brought about is a matter over which there has been considerable dispute, but it has been found that by making the ground connection by a short cable running a few miles out to sea, the trouble may be considerably reduced.

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PLATFORM AND NEWEL STAIRWAY

Morris Williams

THE PRINCIPAL MEASUREMENTS—DETERMINING THE DIMENSIONS OF THE TREADS AND RISERS. CUTTING THE STRINGERS—OBTAINING THE STRETCHOUT OF THE VENEER FOR THE BULL-NOSE STEPS—CUTTING THE NEWEL

EVERY carpenter should be able to construct all classes of stairways that may arise in the practice of his trade. In order to do this, however, he must acquire a certain amount of technical knowledge, which can be had only by careful study of the subject usually designated as "staircase joinery." It is conceded that this class of work calls for more technical knowledge than any other branch of the building trades, and the workman with ordinary common

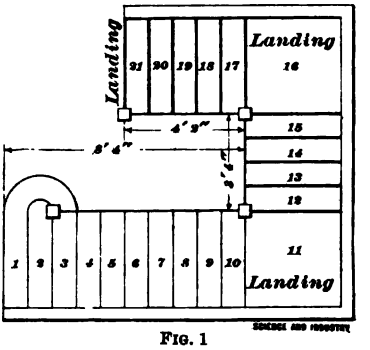

FIG. 1

sense who supplies himself with the requisite knowledge on this subject will attain the top of his trade, and, by virtue of his superior ability, be of greater financial worth to his employers.

That more of our mechanics do not understand staircase joinery can be attributed to the fact that the newel and platform stairways have superseded the geometrical stairways. Today it is all newel and platforms, everything straight, all curves carefully avoided as being out of date and inferior from point of embellishment and utility.

FIG. 2

The writer, while demurring from such ungrounded sentiment, will endeavor to explain the method of constructing a newel and platform stairway. Such a stairway is shown in Fig. 1.

The first thing for a stair builder to do is to take his measurements, the principal ones being the height between floors for the sum of the risers, and the available "going" for the sum of the treads and landings. In the case in hand, the height is 12 feet 10 inches, and the total of the going for the three flights is 15 feet 10 inches. This total is made

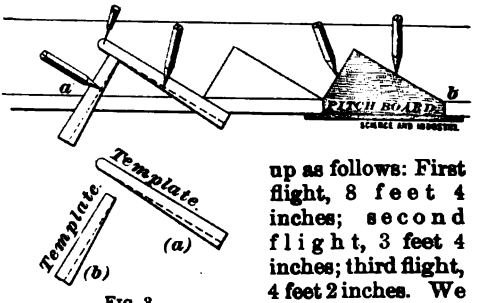

FIG. 3

up as follows: First flight, 8 feet 4 inches; second flight, 3 feet 4 inches; third flight, 4 feet 2 inches. We have also two platforms and one landing to be counted as forming one tread. The height 12 feet 10 inches is to be divided into the number of risers required, in this case 22, which is equal to the combined number of treads and landings. By dividing 12 feet 10 inches by 22, we obtain a rise 7 inches in height. To find the width of the tread, it is necessary to divide the combined going of the three flights, which is 15 feet 10 inches, or 190 inches, by 19, obtaining in this manner 10 inches for the width of the treads. The going is divided by 19 instead of 22, as was done with the height for the riser, because the two platforms and the landing

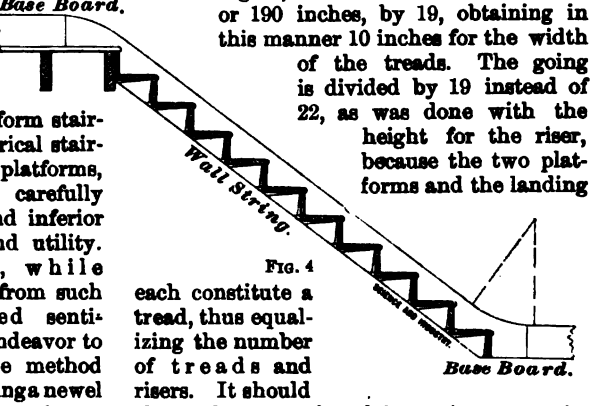

FIG. 4

each constitute a tread, thus equalizing the number of treads and risers. It should always be remembered in setting out stairways that every landing, whether a platform or floor, is to be considered as a tread, and that therefore each flight contains one

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riser in excess of the number of treads. Another thing to consider is the proportioning of treads and risers. From experiment, it has been found that 24 inches is the actual

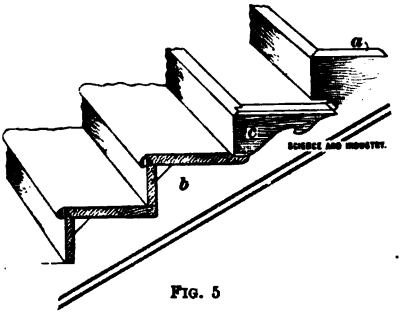

FIG. 5

space covered by a step on a level place, and that 11 inches is the height an ordinary man may raise his foot in stepping vertically. By adding these together, we obtain 35 inches, which is the length of the combined two steps.

It is evident that one step in the stairway will contain one-half of this number, and, in stair building, the steps should be arranged in the proportion of 24 to 11. Thus, if the tread is 12 inches wide, the riser should be 5½ inches, which, in actual construction, is considered the nearest approach possible to perfection in the proportioning of treads and risers, and this proportion, when the staircase admits, should always be adhered to. The product of the riser and tread of an ideal step is 66, and from this a rule has been derived by which it is possible to proportion other steps to meet conditions

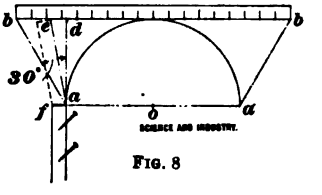

FIG. 8

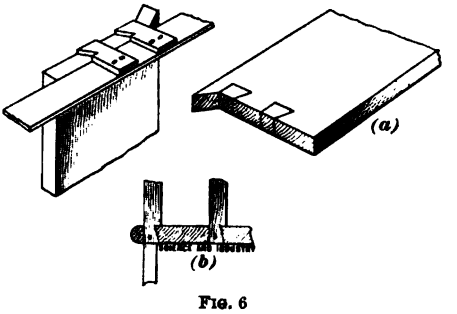

FIG. 6

arising from variant dimensions of heights and goings. This rule consists in dividing either the riser or tread into 66. For instance, assume an 11-inch tread; by dividing 11 into 66, the quotient will be 6 inches, which will be the best proportioned riser

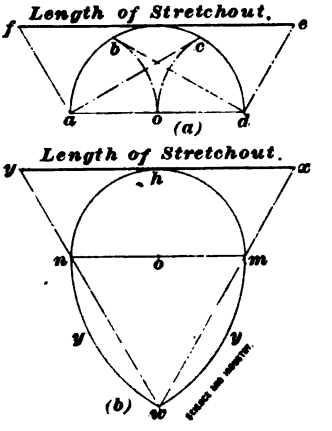

FIG. 7

for a step having this tread. Reversely, assuming the height measurements to call for an 8-inch riser; by dividing 8 into 66 we obtain the quotient 8¼ inches, which will be the best proportioned tread to meet the conditions of easy stepping.

After determining in this manner the width of treads and risers, it becomes necessary to get out what is called a "pitch board." This is shown in Fig. 2. By means of the pitch board the stringers are marked for housing or cutting, as the case may be, applying it as a templet to the stringer in the manner designated in Fig. 3. Two templets are then prepared, one to mark the housing of the treads and the other to mark the housing of the

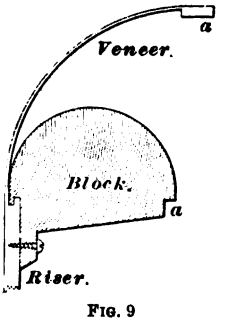

FIG. 9

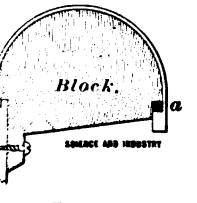

FIG. 10

risers. These templets are shown at (*a*) and (*b*) in Fig. 3. They represent, in thickness, the tread and riser, together with the wedges. In the templet for the tread is placed a

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brad awl, as designated, to hold it in place on the stringer for marking. When the templet is removed, the mark made by the brad awl on the stringer will be the center to insert the brace bit to bore for the housing of the nosing.

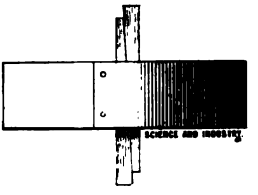
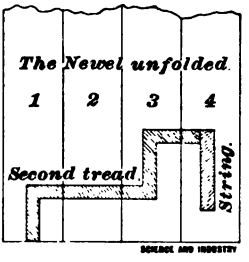


FIG. 11

The wall stringer to the bottom flight is shown in Fig. 4, and illustrates the appearance of the stringer after the application of the pitch board and templets, when it is ready for the housing. The cutting is done by boring holes at the intersection of the treads and risers, as shown in the first step of the stringer, Fig. 4. Then saw along the lines of the housing to the depth of $\frac{3}{8}$ inch, the waste material being removed by a router plane, which leaves the housing clean and uniform in depth.

Fig. 5 is a view of a front-cut stringer. Step *a* shows how it is cut to miter with the riser, and step *c* when brackets are planted on the face of the stringers. The other steps show the mitered treads and risers grooved, tongued, and blocked as at *b*.

It may be interesting to the reader to know how the treads are marked out preparatory to dovetailing for receiving the balusters, and the method is therefore illustrated in Fig. 6. At (*a*), the tread is shown marked and mitered, while at (*b*) a cross-section of a step shows the balusters in position and dovetailed to the end of the tread.



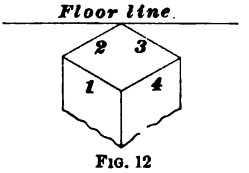


FIG. 12

Referring to Fig. 1, the first two steps in the plan are what are termed bull-nose steps, the curve being a semicircle. The different methods of finding the stretchout of the curved portions are clearly illustrated in Figs. 7 and 8, and can be described as follows: From the center *o*, in Fig. 7 (*a*), draw the semicircle *a b c d*; from *d* and *a* as centers and with *d o* or *a o* as radius, draw the arcs *o c* and *o b*, cutting the semicircle in *b* and *c*. Connect *b d* and *c a* and draw *a f* perpendicular to *a c*, and *d e* perpendicular to *d b*. The length of the stretchout will then be *e f* on the crown tangent. In Fig. 7 (*b*), describe the semicircle *n h m*. From *n* and *m* as centers and *m n* as radius, describe the arcs *n y w* and *m y w*, intersecting each other in *w*. Connect *w m* and extend to *x*; also connect *w n* and extend to *y*. The line *x y* will be the length of the stretchout of the semicircle *n h m*.

The third method is shown in Fig. 8, and the length of the stretchout is obtained by simply drawing an angle of 30° from *a a*, intersecting a line drawn tangent to the crown of the semicircle, as at *b b*. Fig. 8 also illustrates the method of spacing the kerfings in case kerfing is determined on to bend the risers. A piece of stuff of the same thickness as the riser is nailed tangent to the curve, as at the springing *a*; a saw cut is made at *a* to within $\frac{1}{8}$ inch of the opposite side. The piece is then bent until the saw cut is tightly closed, determining the length *d e* on the line *b b*, which is the correct distance between the kerfings.

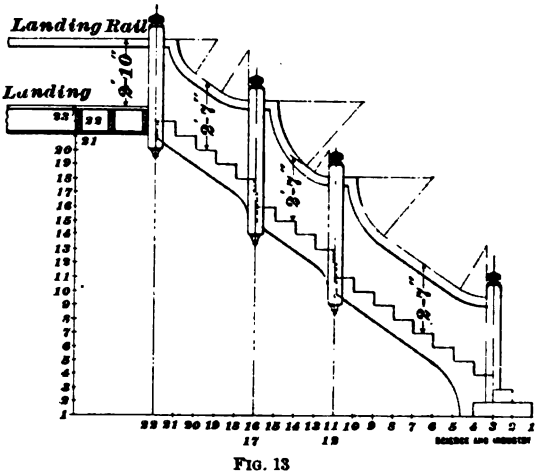


FIG. 13

A better method of bending is shown in Figs. 9 and 10. In this case, the riser is veneered and bent around the block, well glued and wedged tight, as shown in Fig. 10. The method of wedging is designated and further illustrated in Fig. 11, and the placing of the wedges is shown at *a* in Fig. 10. In housing the newel to receive the treads, risers, and stringers, it is advisable to unfold the sides of the newel and mark the dimensions taken from the elevation. This method

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is shown in Fig. 12; the dimensions are taken from the elevation in Fig. 13.

Where many risers and treads are to be housed into the newel, this method always should be adhered to. It insures accuracy and renders the possibility of misplacing the housing unlikely. Fig. 13 illustrates the elevation of Fig. 1. It also shows the ramps and swannecks of the rails, the easements of the stringers, and the length of balusters and newels.

In this article an effort has been made to combine in one example all the difficulties of a platform stairway, and the writer hopes that, while many of the points may be old to our interested readers, some may be new.

INCANDESCENT LAMPS

IN A paper recently read before the Franklin Institute, Mr. Francis W. Wilcox gives some very interesting information relating to incandescent lamps. The incandescent lamp is such a common object that few people realize the vast amount of time and money that has been spent to bring it to its present state of perfection. The annual output of lamps in the United States is now between 15,000,000 and 20,000,000. Not only has the quality of lamps been greatly improved, but their price has been brought down from $1.00 to an average of 18 cents. Lamps that were at one time sold for $1.00 would not now be taken as a gift, so inefficient would they be when compared with modern lamps.

Many people have the impression that the filament of an incandescent lamp is made of carbonized bamboo fiber. This was true of the early lamps, but filaments are now made by the "squirting" process. A mixture of cotton is made and squirted through dies. The threads are then molded to the proper shape and, after the solvent is dried out, baked. This has resulted not only in an enormous cheapening of the filaments, but has also made them very much more uniform. Before this process was introduced, 350 hands were required to cut bamboo for an output of 20,000 lamps per day. With the present method, 25 hands can turn out each day filaments for 40,000 lamps. With the bamboo filament, 90 per cent. of the crude material was wasted, while with the squirting process 95 per cent. is utilized.

Great improvements in the method of joining the filaments and leading-in wires have also helped to reduce the cost of these lamps. One of the more recent important advances is in the matter of exhaustion. The air was formerly taken out by means of mercurial air pumps, batches of 50 to 100 being exhausted at one time, and this prevented individual attention being paid to each lamp during the process. By the present so-called "chemical" method, the air is first exhausted to quite a high degree by means of a mechanical air pump of special design, after which a gas that combines with the residual gases and renders them harmless is introduced into the bulb. Great improvements have also been made in methods of testing the lamps, thus resulting in a much more uniform output.

Notwithstanding all the refinements of manufacture, not more than one-third of a lot of lamps will come out just at the voltage aimed at; in other words, to produce, say, 1,000 lamps of a given voltage, about 3,000 to 4,000 would have to be made, and the 1,000 selected from these. The present tendency is toward lamps of high voltage. The 50-volt lamp was formerly much better than the one made for 100 volts, but there is now no difficulty in making first-rate 100-volt lamps, and the result is that the use of 50 volts is rapidly becoming obsolete.

In the paper referred to, the writer mentions the fact that there are about three times as many 110-volt lamps used as are manufactured. In other words, lamps put out as 110-volt are really 109- or 111-volt lamps. The necessity is urged of stations adopting odd voltages, such as 103, 105, 107, 108, or 109, instead of sticking to the old standards of 104 and 110. If such odd voltages are specified, the station manager is much more apt to get lamps of the voltage called for, because it is impossible to make lamps all come out at the standard voltages.

In the early days, every inventor or manufacturing concern that put forward a system of incandescent lighting thought it necessary to have their own particular style of lamp base. The result was that there were no less than thirteen different lamp bases in use. The number has, however, steadily decreased, until now only three different styles are used to any extent. These three

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are the Edison, Thomson-Houston, and Westinghouse. The use of the two latter is steadily decreasing, and the prospects are that, in course of time, the Edison base will be used almost exclusively. The reason for this is that, all things considered, the Edison is the best base. It is easy to make, because it has few parts, and these are very simple. It also makes good contact in the socket. The Thomson-Houston base is a good one, but it is more expensive to make than the Edison, and, as it entails an extra charge of 1 cent apiece on all lamps with this base, station managers are fitting lamp sockets with adapters, so that Edison base lamps may be used. The Westinghouse base has poor contacts, and these become worse the more the sockets are used. The proportion of the different sockets in use in the United States is estimated as follows:

Edison	55 per cent.
Thomson-Houston	25 per cent.
Westinghouse	15 per cent.
All others	5 per cent.

Lamps as now constructed also maintain their candlepower much better than the older types, made not any further back than ten years ago; and, when one considers the accompanying reduction in price, the advances in the art of making incandescent lamps are truly striking.

THE I. C. S. PIPE-FITTERS' CHART

A Handy Card for Saving Time—Old and New Methods of Taking Pipe Measurements

TIME is money. Anything that will reduce the time necessary to perform a piece of work is a money saver, and should be adopted by all who require it. Some people are very slow in picking up new methods; they are quite conservative in their ideas, and prefer to struggle along, dragging themselves over the old time-worn ruts rather than change to the newer and easier paths that will lead them more quickly and with less resistance to the object of their labors. But our readers are not built that way; if they were they would not be subscribers to Science and Industry.

Mechanics generally have different ways of doing things, and pipe fitters in particular have different ways of taking pipe measurements; and yet, in a way, they all come out about right in the end. Of course, the pipes are sometimes cut too short, and, at other times, they are too long to properly fit in their appointed places, and the fitter, after "trying it in," has the chagrin of hurrying down to the pipe vise to remedy the fault before anybody sees his mistake.

The rule-of-thumb methods employed by pipe fitters in ascertaining the length of a piece of pipe that is intended to be screwed in between two 45° pipe fittings are certainly quite variable. Most of them are unreliable, and many are altogether too long. To assist pipe fitters in taking measurements accurately and quickly, The International Correspondence Schools, of Scranton, Pa., have designed a pipe-fitters' chart, a reduced illustration of which is shown in the accompanying illustration.

This chart is designed with mathematical accuracy, and is destined to be a great help to pipe fitters by enabling them to quickly measure the proper length of a piece of pipe required between two eighth elbows. It is always a simple matter to measure the distance from center to center of the pipes, as shown at *A* in the figure, and this is the only measurement the pipe fitter has to take with his rule in order to determine the length of the diagonal pipe *B*. The figures representing the measurements taken at *A* are shown in white letters near the inner edge of the black ring on the chart. The measurement of the diagonal piece at *B* is found at the outer ring of white figures.

To use the chart, measure the distance square across the pipes from center to center,

Size of Pipe.	Allowance.	Size of Pipe.	Allowance.
⅛ inch	¾ inch	3 inches	2½ inches
¼ inch	1 inch	4 inches	2¾ inches
1 inch	1⅛ inches	4½ inches	3 inches
1¼ inches	1¼ inches	5 inches	3½ inches
1½ inches	1½ inches	6 inches	4 inches
2 inches	1⅞ inches	7 inches	4½ inches
2½ inches	2⅛ inches	8 inches	5½ inches

as shown at *A*. Point off this measurement on the inner circle of figures on the chart. Follow it out radially to the middle white circle and read the number of feet and inches it represents on the outer circle of figures. This gives you the exact measurement from center to center of the 45° elbows. Now subtract from the measurement

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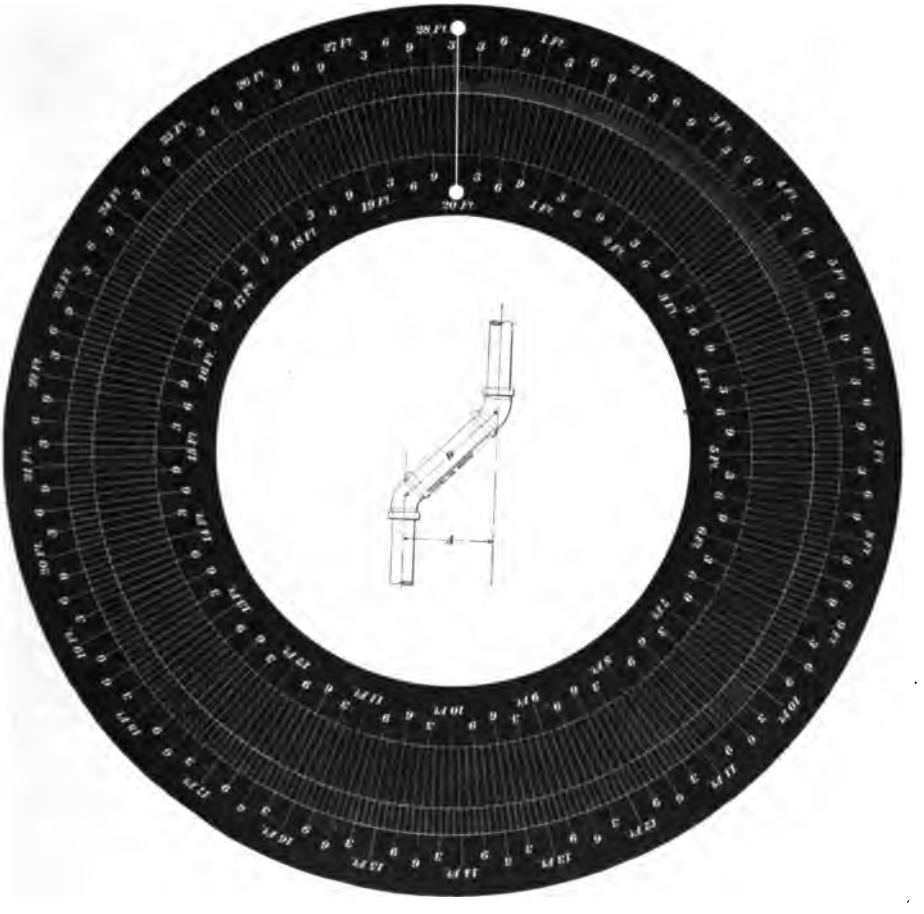
thus found the distance between the ends of the threads and the centers of the 45° elbows, and you will have the length of the pipe *B*.

The accompanying table shows how much

EXAMPLE.—The distance *A* is 7 feet 3 inches. Find the length of 3-inch pipe at *B*.

SOLUTION.—By locating the 7-foot 3-inch mark on the inner circle of figures, and following it out radially to the outer circle of



to allow for both ends if standard threads and cast-iron fittings are used.

Presumably, the best and easiest way for our readers to thoroughly comprehend the chart is to work out an example.

figures, we read 10 feet 3 inches. The allowance for the fittings (see table) is $2\frac{1}{2}$ inches. Therefore, the length of pipe at *B* is 10 feet 3 inches $- 2\frac{1}{2}$ inches $=$ 10 feet $\frac{1}{2}$ inch. Ans.

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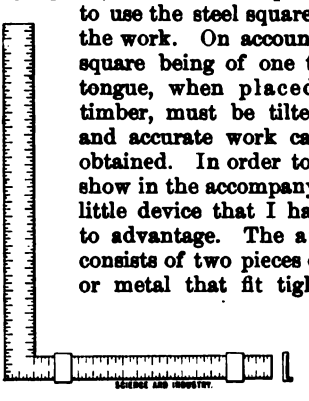
USEFUL IDEAS

A DEVICE FOR THE STEEL SQUARE

John W. Wolfender

WORK is often too wide even for the large try square, and it is consequently necessary to use the steel square in laying out the work. On account of the steel square being of one thickness, the tongue, when placed against the timber, must be tilted somewhat, and accurate work cannot thus be obtained. In order to avoid this, I show in the accompanying sketch a little device that I have often used to advantage. The arrangement consists of two pieces of hard wood or metal that fit tightly over the tongue of the square. The outside leg of the clip extends about ¼ inch, forming a stock for the square. By this arrangement, the square, when placed against the timber, is held in the same plane as the surface of the work, and lies flat on the material, which insures accurate work.



ELECTRICIAN'S BIT

Frank N. Blake, North Adams, Mass.

A GOOD and inexpensive bit for making holes through thick partitions and floors, close to walls and in corners, may be made from a round steel umbrella rib. Put a short piece of wire through the hole at one end and cast a little lead or some harder metal around it to make a shank; flatten the other end a little and sharpen, leaving the hole for fishing wire. In making bits shorter than the full length of the rib, file the end bright and dip into soldering fluid before casting on the shank.

The flexibility of the long bit allows vertical holes to be made through the floor close to the wall or in a corner, which cannot be done with a rigid bit, either in a ratchet bit stock or with an angular boring attachment; it also permits boring with a steady forward motion, while using the ratchet would not.

A FOLDING DRAWING TABLE

George F. Lord

THE study of mechanical or architectural drawing requires the use of a drawing board and set of instruments. It is often convenient, however, to have a table on which the drawing board can be placed, or, better still, have the board so constructed that it is a board and table combined.

Those who have much drawing to do in the evening, after a hard day's work in the office or factory, know that a great amount of time is consumed in removing books and papers from the library or dining-room table in order to make way for the small drawing board not provided with its own supports. If the work upon which a person is engaged occupies many evenings successively, the repeated bother in getting ready to work becomes trying, and the student or draftsman, unable to spare the time thus lost, looks around for a remedy. He finds that he can buy drawing tables that do almost everything but draw; they can be raised and lowered, or twisted this way or that. They are provided with numerous swinging arms, tiers of shelves, casters, and thumbscrews, until they look more like a piece of paper-making machinery than a simple drawing table. These models of mechanical skill are convenient in the extreme, and are all that can be desired by those who can afford to pay the price, and for these our article will be of little interest.

The writer had considerable drawing to do, and realized that the only way he could make progress would be to have a drawing table on which to leave his work, so that he could take it up in spare moments. Not caring to make the necessary outlay for such a table as he would want, he realized that he must be content with an apparatus that would approach, as nearly as possible, the perfection attained by the tables on the market. The first point that he decided was that he could not, for a small cost, make

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a table adjustable in height. It was necessary, therefore, to determine the most convenient height for rapid and easy working, for he had so often, in previous work, found

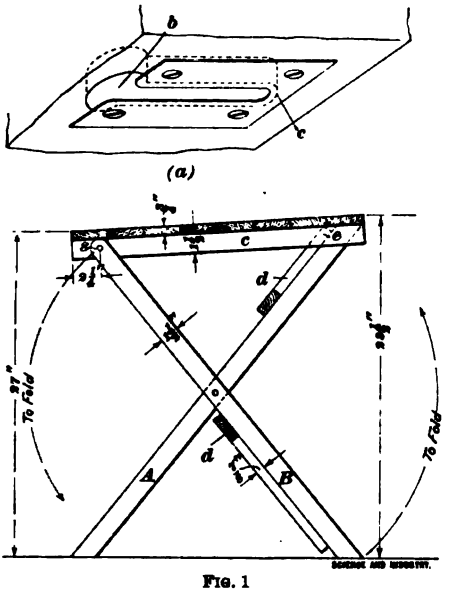

FIG. 1

his arms aching because of the uncomfortable position while seated at the table, and an equally severe backache and tired nerves from standing. While unable to make a table adjustable in height, he felt sure that he could evolve one that could be folded up and stowed away in some convenient closet or hallway.

After sketching and discarding various

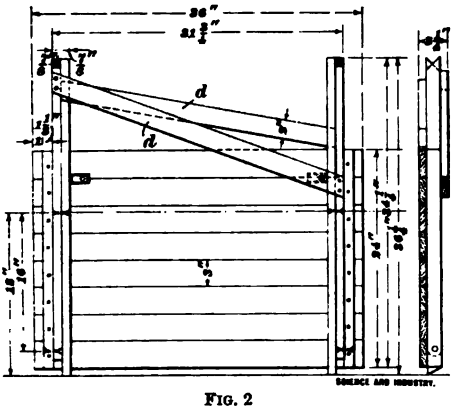

FIG. 2

ideas, he finally decided on the table shown in Figs. 1 and 2. From Fig. 1, which is a side view, it will be observed that the table top is made of several pieces. These pieces are of selected pine, 36 inches long, and 3 inches wide, free from sap streaks or wavy grain, and thoroughly kiln-dried. They were planed and glued together at the planing mill, and left to stand for at least half a day before being planed to the proper thickness. The stock used for the frame was of hard wood, planed square and smooth. The battens at *c* were $1\frac{1}{8}$ in. $\times$ $1\frac{1}{2}$ in., and were screwed firmly to the top. The legs *A* and *B* of the table, made of stock $\frac{7}{8}$ in. $\times$ $1\frac{1}{2}$ in., were likewise dressed at the mill. The feet of the legs were cut at the proper angle, and the top of *B* was rounded off as shown, the upper end of *A* being cut also at the proper angle. Where they cross, they were pivoted with $\frac{3}{4}$-inch stove bolts, small bolts being used at *s*. Both the head of the bolt and the nut should be countersunk in the wood,

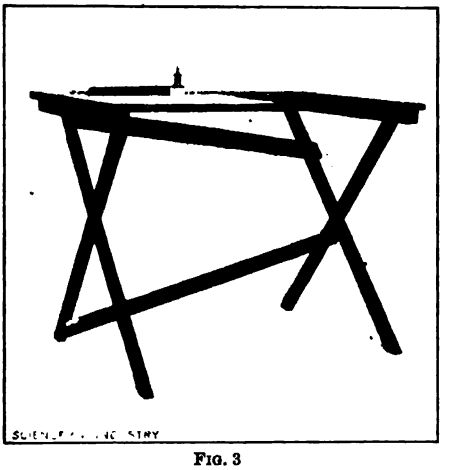

FIG. 3

as otherwise the table will not fold up. In order to lock the end *e* of the leg *A* into the table top, so that the chance of it tilting upward will be avoided, the detail as shown at (*a*) was schemed out. A piece of heavy sheet metal was cut out as shown and screwed over a slotted hole with an enlarged end cut in the under side of the table top. A heavy round-headed screw was then placed in the top of the leg *A* and screwed down until the distance between the end wood and the under side of the head was little more than the thickness of the sheet iron. The slot in the sheet iron was of the same width as the diameter of the screw. In placing the table from a folded position to an upright one, the screw head is inserted in the opening *b* and slid along the slot until it reaches a bearing *c*.

In order to prevent the top of this leg

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from getting out of position while the draftsman is at work, a couple of cupboard latches were placed at *e*, and after the legs *A* have been slid into position these latches enter back of the legs and hold them in place. The cupboard latches were attached to each other by a taut wire, which, when pulled, would release them and allow the table to be folded.

FIG. 4

Braces, as at *d*, *d*, are necessary in order to stiffen the table longitudinally. These braces were first put directly across, but it was found that they allowed too much vibration in the table, and new ones were placed diagonally, as shown at *d*, *d*, Figs. 1 and 2. In order to release the pressure on the springs of the cupboard latches when the board is folded up, it is well to cut two small holes in the sides of the legs that lie against the latched ends when the table is closed. This allows the latched bolt to spring into place.

When the table is complete, it cannot collapse, and it will be found very firm, considering the light construction, and will easily bear the weight of a man.

The writer said in the forepart of the article that the table could not be adjusted in height. It can, to a certain extent, by putting a number of slotted holes, as at (*a*), Fig. 1, under the batten *c*. This will draw the legs together at the top and bottom and, of course, raise the height of the board. The feet, however, will not rest upon the floor in the different positions unless they are rounded, and it does not seem advisable to do this, as it lessens the strength of the legs.

The table erected ready for work is shown in Fig. 3. It has a neat appearance, as can be seen, and really becomes an article of furniture when the hard wood is filled and well finished with shellac or oil. Closed, it has the appearance shown in Fig. 4, and occupies, in this position, a width of 3½ inches, outside measurement. The cost will vary according to circumstances, but $2.00 is a safe limit. This price, of course, does not include the labor, which the draftsman is supposed to perform himself. It is not inconsiderable, but, at the same time, the results are highly gratifying in convenience, efficiency, and appearance.

PUTTING A LINER IN A PUMP CYLINDER

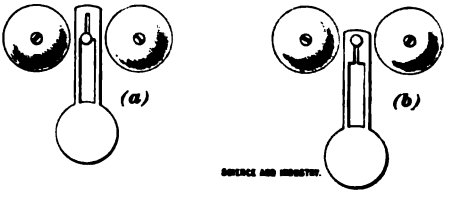
W. K., New Cumberland, W. Va.

HAVING occasion, the other day, to put a liner in a pump, and having no screw press, I hit upon the following scheme, which may be worth noting for the use of some of your readers. I turned a pin to a loose fit in the liner, giving it a head to bear on the end of the liner. I then put a screw jack in position on the head of the pin and passed a chain around the jack and cylinder, securing it to the latter. The liner was then greased and the jack screwed out, the result being that the liner entered the cylinder steadily and easily, the apparatus constituting, in effect, a rough screw press.

TELEPHONE CALL INDICATOR

J. J. Reinhold, Marietta, Pa.

IN THE accompanying figure is shown an extremely simple device that is very useful in connection with telephone bells. The call indicator, the shape of which is shown in the figure, can readily be cut from heavy paper in a few minutes. It is slipped over the bell hammer and normally hangs on the hammer rod, as shown at (*a*). When the bell rings, the vibration of the hammer immediately causes the indicator to fall into the position shown at (*b*). It is so simple that further explanation seems unnecessary.



By placing one of these indicators on each bell, parties having two telephones can readily tell from the positions of the indicators, without seeing the bells or knowing them by their tones, which bell has been rung. Furthermore, if a call came in while the subscriber was out of hearing of his telephone, on his return the position of the indicator would inform him of that fact. On toll-line switchboards, where bells are used in place of annunciators, such an indicator would be very useful.

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EDITORIAL COMMENT

MASTERY OF MEMORIZING

We call attention to an advertisement elsewhere of "Mastery of Memorizing," published by Jas. P. Downs, P. O. Box 1202, New York, N. Y. Any system that will really aid the memory is to be heartily commended; but it should be borne in mind that the mere reading of such a book will not assist one—this system (or any other) must be thoroughly studied and practiced before improvement can begin. Send to the above address for a copy of the memory booklet, which is mailed free to all applicants.

HAND FORMING TOOL

The Wallace Supply Company, 56 Fifth Avenue, Chicago, Ill., makes a clever device for the use of blacksmith shops and machine shops that is especially adapted to the forming of eyebolts, hooks, loops, and rings by hand power. The device, which is shown in the accompanying illustration, is made in two sizes, of which the smaller takes stock up to ½ inch in diameter, and the larger from ½ to ¾ inch in diameter. Loops or rings can be made from the smallest size up to 3 inches, outside diameter, with great ease; it is claimed that one man can form 1,200 pieces per day from ½-inch stock. The light weight of this device, its low price, and its adaptability to numerous forms and sizes of stock, make it a tool within the reach of the smallest shop; its usefulness will be equally apparent in the large shop. For any further information, address the makers.

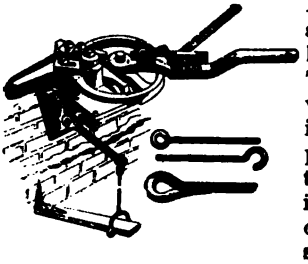

TABLE OF PLATE AND RIVET VALUES

Mr. Thomas H. Craft, 16 Kelton Street, Cleveland, Ohio, has favored us with a copy of his table of plate and rivet values, which is very useful for boiler designers, boilermakers, boiler inspectors, and engineers. The table gives the strength of the net section of the plate between two rivet holes for all commercial sizes of plate from ¼ inch to 1⅝ inches in thickness; for all widths from 1 inch to 4½ inches, varying by thirty-seconds of an inch; and for tensile strengths of 45,000, 50,000, 55,000, and 60,000 pounds per square inch. It also gives the values of rivets in single shear and double shear for all commercial rivet diameters from ⅝ inch to 1⅞ inches, based on shearing values of 38,000, 40,000, 42,000, and 44,000 pounds per square inch.

This table should prove a great time saver in making calculations for the efficiency of riveted joints, since it reduces the calculations necessary to the lowest limit possible. The table is cloth-bound, and of such shape as to be carried in the pocket. Mr. Craft is prepared to supply them at the price of $1.00.

BOOK NOTICES

Practical Electricity. Published by the Cleveland Armature Works, Cleveland, Ohio. Second edition, flexible cloth, 286 pages, 83 illustrations. Price $2.00.

The first edition of this work was published last year, and was noticed in our January, 1900, issue. We are glad to note that a second edition has been required in such a short time. Its rapid sale indicates its popularity. The publishers advertise that if the book does not prove satisfactory and is returned in good condition, they will refund the price paid—a somewhat remarkable statement in an advertisement of a book.

Steel-Plate Chimneys: Drawings, Tables, and Specifications. The Standard Engineering Company, Pittsburg, Pa. Price $1.00.

This work consists of a drawing of a steel-plate chimney, including complete details of masonry foundation, foundation bolts and washers, base plate, top plate, etc., with all connections. The drawing is accompanied by tables of dimensions by means of which it can be made to serve for the construction of 45 different sizes of chimneys, ranging from a flue diameter of 30 inches and a height of 70 feet up to a flue diameter of 11 feet and a height of 300 feet. The tables also contain such useful information regarding the different sizes as the weights of the different portions, the horsepower of boilers for which they are adapted, etc. Accompanying the drawing and tables is a specification form, which, when filled in to correspond with the values given in the drawing and tables, will make a basis for a contract for the complete chimney, including foundations. The design seems to be based on correct principles, and the details are all carefully worked out.

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ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*
2. *Only questions of general interest to our readers will be answered.*
3. *No questions will be answered by mail.*
4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*
5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*
6. *Reference to inquiries previously answered should give date of issue and number of question.*
7. *Questions cannot be answered in the issue of the month immediately following their receipt.*
8. *Any book not out of print and for sale by regular dealers may be ordered through the magazine.*
9. *We will not undertake to calculate windings of dynamos and motors, as this involves considerable work and is seldom justified.*

---

(347) How is a piece of iron roofing cut to fit around a 32" smokestack on a roof with one-third pitch? Please give an answer that may be applied to work on any pitch. G. W. L., Schultz, Ariz.

ANS.—See answer to question No. 355 (*b*), Answers to Inquiries, in the December, 1899, issue.

***

(348) Some weeks ago I received a communication that was apparently written in ordinary writing ink. A few days ago I had occasion to refer to this letter and was surprised to find that the writing had entirely disappeared. Can you tell me how and from what such an ink is made, or of a chemical that will act in this way? C. R. J., Port Chester, N. Y.

ANS.—Two preparations of vanishing inks are known to us. The first one, originated in Paris and sold under the name of "Encre pour les dames," is an aqueous solution of iodide of starch; it writes blue, and disappears entirely in from 3 to 4 weeks. A black ink that will disappear after a short time is prepared by boiling nutgalls in alcohol, adding copper sulphate and sal ammoniac, and when cold a little gum is dissolved in it. Writing done with this preparation will vanish in about 24 hours.

***

(349) If a ground detector is connected to the primary circuit of an alternating-current dynamo, will it detect a ground on the secondary side? Please explain. H. M., Westbrook, Me.

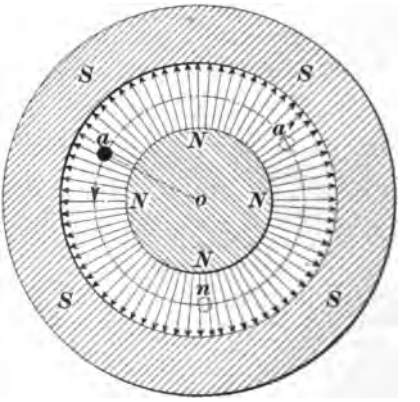
ANS.—If all the transformers are in good order, the various secondary circuits will be entirely separate from the primary, and under such circumstances a ground in the secondary will not be indicated by a ground detector attached to the primary. If, however, there should be a leak or poor insulation between the primary and secondary coils of any of the transformers on the line, a ground on the secondary would be indicated by a detector attached to the primary, because the ground would then be practically connected to the primary.

***

(350) In a work on electricity that I have been reading lately, dynamos are classed as (1) unipolar, (2) bipolar, and (3) multipolar. I understand the last two classes, but will you please inform me whether a dynamo can be run with one pole, or, in other words, what is a unipolar dynamo?

H. D., Lowell, Mass.

ANS.—The term *unipolar* dynamo is, in a sense, a misnomer. These machines have in reality two poles, but the poles are so arranged that the armature conductors always cut the lines of force in one direction; hence, no commutator is necessary in order to produce a continuous current. For example, the accompanying figure shows one arrangement of a so-called unipolar dynamo. The outer pole *S* is angular in shape, and surrounds the inner pole *N*. If a conductor *a* is revolved in this space, it will always cut lines in the same direction, whereas in an ordinary dynamo, the direction of cutting reverses as the conductor moves under alternate poles. If the ends of *a* are connected through sliding contacts, a continuous current will result. Other conductors *a'* and



n might be connected in parallel with *a*, or, if a pair of sliding contacts were used for each, they could all be connected in series. Unipolar dynamos cannot be made to give a high electromotive force without using several of these sliding contacts; hence they have never been used to any extent.

***

(351) (*a*) What factor of safety is usually allowed in large structural-steel buildings? (*b*) Is not the strength and stiffness of such buildings entirely dependent on the steel framework? (*c*) After a building is completed, is any provision made for the regular inspection of the framework, to see whether there is any deterioration? (*d*) What is the estimated life of a steel-frame building, and is there any probability, after 300 or 400 years, or even longer, that a building of this kind may suddenly collapse, due to the weakening of the steel frame caused by oxidation? S. D. C., Washington, D. C.

ANS.—(*a*) In mill buildings, etc., a factor of safety of 3 is usually allowed. In tall office buildings, the factor of safety may be from 4 to 6. Usually, however, it is about 4. These low factors are used because steel, as now manufactured, is an extremely reliable material. (*b*) Such buildings are not entirely dependent on the steel frame for stiffness and resistance against wind pressure. The stone and terra-cotta walls, and the transverse partitions of expanded metal and plaster, or of fireproof tile, all tend greatly to reenforce the structure. The floors, of course, are entirely dependent on the steel

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columns for support. In buildings of steel construction up to 12 stories in height, provision is seldom made for wind bracing, but for buildings of greater height than this, diagonal rods or heavy knee braces are usually provided. (*c*) There is no chance for regular inspection of the framework after a building of the modern office type has been erected, for all the floorbeams and columns are usually incased with fireproofing material that cannot be removed without destroying it. The exterior columns are likewise incased in the walls, no provision being made for inspection. (*d*) There is little data from which the probable life of the steel frame as employed in buildings of the office type can be even approximated, but it has been determined from buildings of this character erected 20 years, that the corrosion of the steel is extremely slight. It would not be a rash statement to say that the life of such buildings, so far as the steel framework is concerned, would extend considerably over the period of 100 years. It has been found, and especially is it true in this country, that any building other than an ecclesiastical edifice outlives its usefulness in a century, and it is hardly probable that even the magnificent modern office buildings will fulfil the requirements of the locality in which they are placed 100 years from now. That they will be required 300 or 400 years is highly improbable.

***

(352) Tell me what to use in order to stain white maple to a mahogany color.

H. C. L., Stanwick, N. J.

ANS.—An almost perfect imitation of mahogany can be obtained by staining white maple. In order to obtain the stain, mix rose pink and burnt umber in oil. As maple is a close-grained wood, it is unnecessary to use any filler. After the stain has had time to dry, it can be finished with varnish in the usual way.

***

(353) (*a*) What other metal besides zinc may be used in a sal-ammoniac battery? (*b*) What is a good flux to clear melted brass and make it run solid?

W. B. M., Baltimore, Md.

ANS.—(*a*) There is no metal other than zinc that you can use to advantage in a sal-ammoniac battery. (*b*) The addition of a small quantity of arsenic is said to improve brass castings; skill in molding is, however, the essential thing in order to secure good brass castings. Proper venting of the molds and pouring at the right temperature are the main points to be observed.

***

(354) Please inform me whether there is a book that treats on dissolving or removing boiler scale.

B. L. H., Lowell, Mass.

ANS.—"A Treatise on Steam-Boiler Incrustation and Methods for Preventing Corrosion and the Formation of Scale," by Charles Thomas Davis, price $1.50, is the only book on this subject with which we are acquainted. It can be obtained from The Technical Supply Co., Scranton, Pa.

***

(355) Having had occasion to boil the wheels of a carriage in linseed oil, for the purpose of protecting the wood as well as to tighten the tires, I found that by drying them thoroughly in the sun before boiling, they took the oil without swelling, and in consequence the tires are not tight. By soaking them thoroughly in water, however, before boiling in the oil, the oil seems to take the place of the water, leaving the wood swollen and the tire tight on the wheel, most oil being absorbed by the last method. Please give me the reason for the difference in the results of the two methods.

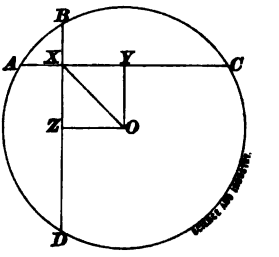
H. S. M., Haddam, Kan.

ANS.—It is difficult to explain. Soaking wood in water usually has a beneficial effect, as it tends to wash out the sap, which is the fermenting property in the wood, and causes decay. Why it is that the latter method produces the effect which you speak of we do not positively know. However, it seems that by soaking the wood in the water it swells the cells, and when the wood is placed in the oil the capillary attraction of the wet wood is greater than if it were dry. This can be illustrated by a piece of blotting paper, which will absorb ink with greater rapidity when it is wet than when it is dry, and such we think might be the case with the wood you speak of.

***

(356) Kindly show how to calculate the area of the circle in the accompanying sketch, in which $AC = 60$ rd., $BD = 70$ rd., $OX = 40$ rd., AXB = right angle.

C. F. D., Phillipsburg, Mont.



ANS.—From the right triangle AYO, we have

$$\overline{AY}^2 + \overline{OY}^2 = \overline{OA}^2 = R^2. \quad (1)$$

From the right triangle BZO, we have

$$\overline{BZ}^2 + \overline{OZ}^2 = \overline{OB}^2 = R^2. \quad (2)$$

Adding (1) and (2), we get

$$\overline{AY}^2 + \overline{BZ}^2 + \overline{OY}^2 + \overline{OZ}^2 = 2R^2. \quad (3)$$

Also, $\overline{OY}^2 + \overline{OZ}^2 = \overline{OY}^2 + \overline{YX}^2 = \overline{OX}^2$.

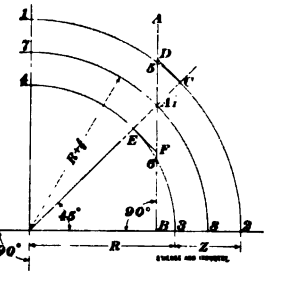
Therefore, $\overline{AY}^2 + \overline{BZ}^2 + \overline{OX}^2 = 2R^2$, or $(\frac{1}{2}AC)^2 + (\frac{1}{2}BD)^2 + \overline{OX}^2 = 2R^2$; whence, $R = 48.156$ rd. The area of the circle is equal to $3.1416R^2 = 5{,}851.2$ sq. rd.

***

(357) In the accompanying sketch, the line AB is drawn through the point A_1, as shown. Is the area 1564 equal to the area 5236? In other words, does the line AB bisect the quadrantal area 1234?

C. K. H.

ANS.—The line AB does not exactly bisect the area 1234; for, it can be shown that the area 1564 exceeds the area 5236 by twice the sum of the areas of the two curvilinear triangles $DC5$ and $EF6$. To prove this, we have, evidently, $15A_17 + 5CA_1 = 528A_1 - 5CA_1$. Also, $7A_164 - A_16E = A_1836 + A_16E$. Adding these two equations, we have $15A_17 + 7A_164 + 5CA_1 - A_16E = 528A_1 + A_1836 - 5CA_1 + A_16E$. Therefore, $1564 + 5CA_1 - A_16E = 5236 - 5CA_1 + A_16E$. Whence, by transposing, we get $1564 - 5236 = 2(A_16E) - 2(5CA_1)$. But, $A_16E = A_1FE + EF6$, and $5CA_1 = A_1DC - DC5$. Also, $A_1FE = A_1DC$. Hence, $2(A_16E) - 2(5CA_1) = 2(EF6) + 2(DC5)$. Therefore, $1564 - 5236 = 2(EF6) + 2(DC5)$. That is, the area 1564 exceeds the area 5236 by twice the sum of the curvilinear areas $DC5$ and $EF6$.



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(358) A planer cylinder with four knives makes 4,000 revolutions per minute, while the board that is being planed is fed under the cylinder at a rate of 52 ft. per minute. What will be the distance between two successive marks of the planer knives on the board?

W. B. S., Hermansville, Mich.

ANS.—Since the cylinder has four knives and makes

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4,000 revolutions per minute, there will be $4 \times 4{,}000 = 16{,}000$ cuts, or knife marks, made on the board while it is moving 52 ft., or $52 \times 12 = 624$ in. The distance between two successive marks will therefore be $624 \div 16{,}000 = .039$ in. This is very nearly $\frac{1}{25}$ in.

***

(359) Fig. 1 shows the projection of the stairway in a room. It would be interesting to know how to miter the mold around the stairway, or the best way to stop the mold.

W. W. Y., Washington, D. C.

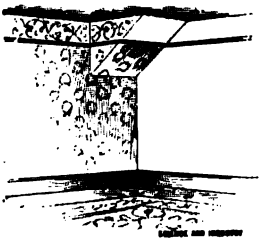

FIG. 1

ANS. — This is an awkward condition, and often occurs. The difficulty exists not only in mitering the molding, but also in the fact that the frieze upon the oblique surface or soffit of the stairs will be much wider than that on the vertical wall, and, where a figured frieze on wall paper is used, it cannot be made to look well. Where such a condition exists, it would be advisable to use a plain frieze colored or papered to match the ceiling. If you carry the mold across the oblique surface, it would necessarily be a special molding developed to suit the miter, and, in any case, it would be awkward looking, and far from artistic. We would prefer to provide a vertical surface extending below the line of molding, and then cove to meet the wall, as shown in Fig. 2. The molding could then be carried around the vertical surface. Another way would be to provide a flat soffit under the molding of sufficient width to place the molding in its normal position, and then carry the molding around the returns, as would be done with a vertical surface. This is shown in Fig. 3.

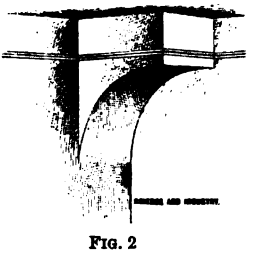

FIG. 2

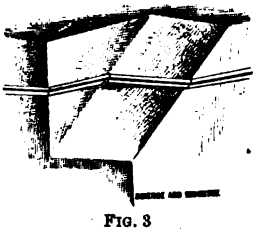

FIG. 3

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(360) I have patented a valve gear to be used on Corliss engines. This gear opens and closes the valves, both steam and exhaust, instantly. (*a*) What would be the difference between a theoretical diagram from an engine with this gear and one with the regular Corliss gear (1) in height and length, and (2) in distance between the clearance and admission lines and between the exhaust and atmospheric lines? (*b*) Would an engine with such a valve gear have any more power than one of the same size with the regular Corliss gear; if so, about what per cent.?

C. A. C., Madison, Wis.

ANS.—(*a*) (1) The height of an indicator diagram depends on the steam pressure in the steam chest, the size and amount of opening of the steam port, the speed of the piston, and the scale of the indicator spring. A valve gear that opens the valve wide just at the beginning of the stroke will permit the cylinder to be filled promptly with steam at nearly the full pressure in the steam chest, and will thus produce a diagram whose height depends principally on the steam pressure and the scale of the spring. The Corliss gear gives a very quick valve opening, and it is doubtful whether any other gear will produce results that will show any appreciable difference in this respect. The length of the diagram depends entirely on the reducing motion, and is independent of the type of valve gear. (2) There would be no difference in the two diagrams in the distance between clearance and admission lines: this distance is governed solely by the volume of the clearance space, and not by the style of valve gear or the speed with which the valves open. There would probably be a somewhat more prompt release with your gear: this would permit the steam to leave the cylinder a very little earlier than in the ordinary gear, and would cause the back-pressure line to become parallel with the atmospheric line a little earlier in the stroke. With the same size of ports, however, there would be practically no difference in the distance between back pressure and atmospheric lines after they became parallel. (*b*) There would be practically no difference in the power that would be obtained with the two types of gear.

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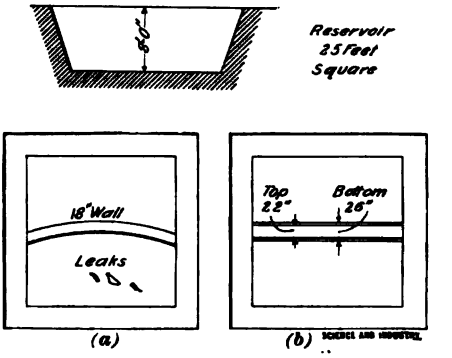
(361) The reservoir shown at (*a*) in the accompanying sketch leaks on one side. The owners desire



to repair the reservoir and at the same time keep one side full of water. They propose that an 18" wall be built, as shown at (*a*), but I think a straight wall of heavier construction, as at (*b*), would be better. What is your opinion regarding the best manner to proceed in order to repair the work, keeping one-half of the reservoir in commission?

J. M., Belleville, Ill.

ANS.—The reservoir is of such small size that we fail to see the necessity of building the wall. In order to construct the wall, the reservoir would have to be emptied, and the time required to construct the wall and the time necessary for it to set would seem to be ample in which to make thorough repairs to the small portion included in one-half of the reservoir. We would, however, suggest that, instead of the masonry wall, you use one of timber, which could be constructed on the ground and put in place in a couple of hours. The reservoir would thus be out of commission a very much less time than would be required to construct either of the walls. The timber side or apron could be covered with tarpaulin to make it water-tight, and it could be braced by shoring from the walls of the reservoir. The joints between it and the walls could be calked with oakum and tarred or made tight with cement or white lead. The cost of such construction would

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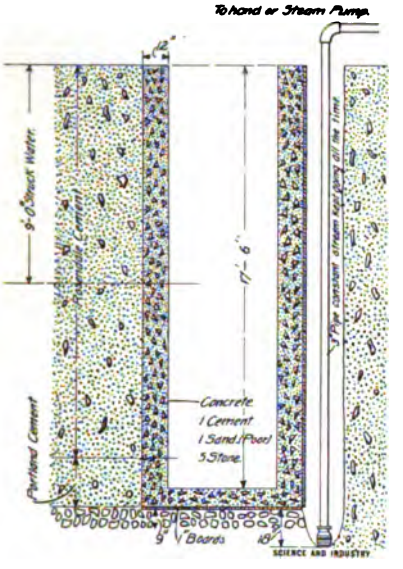
probably be no more than for the erection of the wall, and the timber dam could be kept and used should the other side of the reservoir give out.

***

(362) What is the best method to use in making the water-tight pit shown in the enclosed sketch, using concrete for the walls and floor?
X. Y. Z., Boston, Mass.

ANS.—We think that the method of construction that you employed is as good as any. The only



improvement that we can suggest would be in the interior crating, which we think would be better if the ordinary cement coating were protected by mixing pure Pozzuolana cement and water to the consistency of cream and applying with a whitewash brush. This forms a waterproof coating that is much recommended for cisterns and reservoirs.

***

(363) I have an induction coil wound with silk-covered wire with paper between each layer. The wire was varnished with shellac as it was wound. The coil was wound too tight, and a number of the turns have slipped down between the coil and the end-pieces so that the coil will have to be rewound. The wire on the coil is quite valuable, and I would like to get it off without destroying the insulation. How can I soften up the shellac so as to do this?
W. J. L., Neepawa, Manitoba.

ANS.—The only way we know of to accomplish this is to soak the coil in alcohol until the shellac on the outer layers has become thoroughly softened. Then unwind these layers and allow the coil to soak further, so that the next layers will be softened, and so on until all the wire is removed. A few layers will likely have to be removed at a time, as it would be almost impossible to get the shellac softened all through the coil.

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(364) I have two 6-watt generators that will not generate. I have tried them both as series and shunt dynamos, and have also excited their fields separately. I have also tried to make one machine, operating as a shunt dynamo, excite the field of the other machine, but could get no current from the latter armature. I run them at about 2,500 R. P. M. They have wrought-iron field cores, one field spool, and eight sections in the commutator. The armatures are not laminated, and they are wound for 5 or 10 volts. Both machines will run as motors, but they will not start themselves. Is not this sticking due to incorrect setting of the brushes? Please advise as to the trouble. H. D. T., Denver, Colo.

ANS.—The principal trouble with these machines is that they are too small to run as generators and excite their own fields. Many small machines will operate all right as motors, but will not run as dynamos on account of their inability to excite their own fields. We see no reason, however, why they should not generate if they are separately excited. It may be that they did generate some voltage, but the field strength and speed were not large enough to make the pressure noticeable. The fact that the armature sticks does not necessarily indicate a wrong location of the brushes. This often occurs in small motors when the air gap is very short and the teeth in the armature coarse, thus making it necessary to give the motor a start. If you wish to run these little machines as generators, about the best way would be to separately excite their fields from an outside source, capable of supplying current enough to magnetize the fields in good shape.

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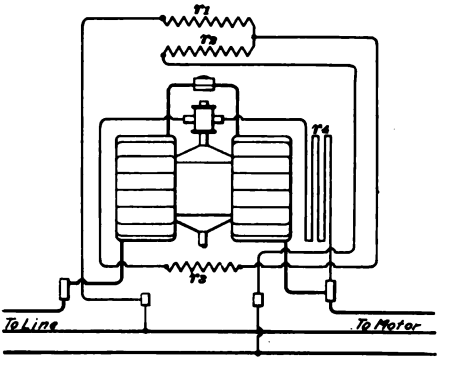
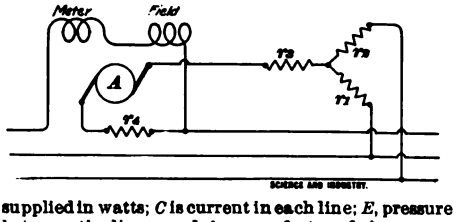
(365) (*a*) Please give and explain a simple formula for calculating the power supplied to three-phase induction motors. (*b*) Please give a sketch showing how a recording wattmeter is used to measure the power supplied. The wattmeter that I have has a V resistance; what is this resistance used for? (*c*) Give title of a good book on power measurement. C. J. C., Jamestown, Cal.

ANS.—(*a*) The best method of measuring power supplied to an induction motor is to use a recording wattmeter. However, you may obtain approximately the power supplied by means of the following formula: $W = 1.732 \times C \times E \times f$. W is the power





supplied in watts; C is current in each line; E, pressure between the lines; and f, power factor of the motor. This takes it for granted that the phases are equally loaded, i.e., that the current in each of the three lines is the same. This will be very nearly the case with any good three-phase motor. The power factor f will vary somewhat with the load, but may be taken as .85 to .87 if the motor is running near full

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load, or about .80 if running in the neighborhood of ½ or ¾ load. For example, suppose a motor is running at full load and takes a current of 40 amperes at a pressure of 500 volts; the number of watts supplied to it will be $W = 1.732 \times 40 \times 500 \times .85 = 29{,}444$; or, since 1 H. P. = 746 watts, the horsepower supplied will be $\frac{29{,}444}{746} = 39.5$, nearly. This is the power delivered to the motor from the line; if the power actually delivered at the pulley were required, the above would have to be divided by the efficiency of the motor, which would probably lie between .80 and .90, depending on the size of the machine. (*b*) The accompanying figure shows how to connect up a recording wattmeter with a Y resistance so as to measure power on a balanced three-phase circuit. The meters are usually calibrated so that the meter reading, multiplied by the constant of the meter, if there is one, gives the total work absorbed by the motor during the given time. The Y resistance has to be used in order to obtain an artificial neutral point for the three-phase voltages similar to the common connection in a three-phase Y-connected armature winding. The equivalent connections are shown in the small diagram; r_4 represents the resistance of the armature circuit of the wattmeter, and $r_3 + r_4 = r_1 = r_2$. (*c*) A book entitled "Modern Polyphase Apparatus and Systems," by Maurice A. Oudin, has some material in it on the measurement of power in polyphase circuits. If you wish a book treating on both mechanical and electrical power measurement, we can recommend "Dynamometers and the Measurement of Power," by Flather. Either of the above my be obtained from The Technical Supply Co., Scranton, Pa.

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(366) (*a*) How do you find the size and distance apart of staybolts in a well-made boiler? (*b*) What should be the temperature of the water in the hotwell when there is a vacuum in condenser equal to 27½ in. of mercury? W. H. H. H., Washington, D. C.

ANS.—(*a*) A very complete outline of the methods to be used in making calculations for boiler stays is given in an article entitled "The Bracing of Steam Boilers," in the April number of this magazine. (*b*) With a surface condenser, the temperature would be nearly 108½°; with a jet condenser, the temperature would be somewhat lower, depending on the care with which the supply of condensing water is regulated and the completeness with which the air pump does its work.

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(367) (*a*) What use has been made of sawdust and shavings? (*b*) Do you know of any place where sawdust is being used on a large scale for other purposes than fuel? (*c*) Can paper be made from it? (*d*) Please give the title of some book relating to the above subject. X. Y. Z.

ANS.—(*a*) The most important use of sawdust and shavings is as fuel in the immediate neighborhood of their production. Sawdust is used also in the manufacture of pyroligneous acid by the dry-distillation process; as a non-conductor between the outer and inner walls of ice houses; as a means of preventing the layers of stored ice from freezing into one mass; and in many other similar ways. (*b*) An important use of shavings is in the manufacture of vinegar by what is called the "quick process." Large tuns of oak, usually about 13 ft. high, 15 ft. wide below and 14 ft. above, are provided with perforated bottoms and filled with shavings. The alcoholic solution to be oxidized percolating through these shavings is rapidly changed into vinegar. (*c*) Sawdust cannot be used advantageously in paper making. Wood fiber for paper pulp is obtained by means of ordinary grindstones, under water. The object is to obtain the fiber of as great length as possible. Sawing cuts the fibers, so that paper made from sawdust lacks tenacity. (*d*) We know of no book of the kind you want.

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(368) (*a*) On what principle is the electromagnetic system of car traction based? (*b*) Show by a sketch the arrangement of batteries and generators with a booster regulator. (*c*) How would you adjust the booster so that the mean charge in the battery shall always be constant? (*d*) Describe by a sketch the manner of testing insulation resistance by means of a ballistic galvanometer.

C. T. H., New Haven, Conn.

ANS.—(*a*) In the electromagnetic system of traction, the working conductor from which the car

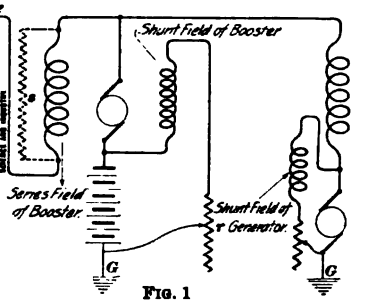

FIG. 1

receives current is split up into sections that are only connected to the feeder during the interval that the car is passing. The sections are switched on and off by means of switches placed in weatherproof boxes between the rails, and these switches are operated by means of magnets carried under the car. (*b*) There are a number of different methods in use for connecting up batteries with a booster. One of these is shown in Fig. 1. The booster has two field windings, one being in series with the line and the other connected across the battery in series with an adjustable resistance *r*. The series winding opposes the shunt winding. When the load is light,

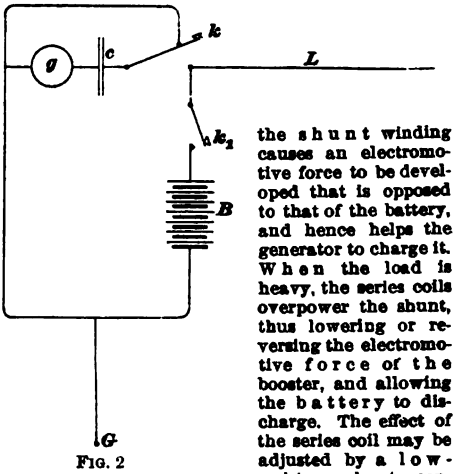

FIG. 2

the shunt winding causes an electromotive force to be developed that is opposed to that of the battery, and hence helps the generator to charge it. When the load is heavy, the series coils overpower the shunt, thus lowering or reversing the electromotive force of the booster, and allowing the battery to discharge. The effect of the series coil may be adjusted by a low-resistance shunt *s* connected across it. (*c*) The effect of the booster on the charge and discharge may be adjusted by varying the resistances *r* and *s*. By taking a series of readings at definite intervals on the battery ammeter, you can easily form an estimate as to when the mean charge and discharge are about equal. (*d*) Disconnect the

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distant end of the cable and connect up a small condenser c ($\frac{1}{10}$ microfarad), battery B, and ballistic galvanometer g, as shown in Fig. 2. See that all these are thoroughly insulated. Press keys k and k_1 so that the battery will charge both cable and condenser. When the deflection of g has become zero, indicating a steady charge, release k and take the throw d_1, representing the full charge of the cable. Press k again, and after, say, 30 seconds, raise k_1 so that the battery is disconnected, and the charge allowed to leak from the cable for a length of time t, say about 5 minutes. Then release k and take the throw d_2. This will be smaller than d_1 on account of the leakage. The insulation will then be given by the formula

$$I = \frac{26.06\, t}{K \log \frac{d_1}{d_2}},$$

where I is the insulation resistance in megohms, and t is the time in minutes during which the charge is allowed to leak. K is the capacity of the cable in microfarads.

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(369) Please give a way to lay off a curved elbow suitable for a stove. J. A. S., Edgard, La.

ANS.—See Answers to Inquiries, No. 85, in the April, 1899, issue.

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(370) If there are twelve $\frac{1}{2}$" pipes branching from a main, and each pipe has twelve nipples with $\frac{1}{16}$" holes tapped into it, how large must the main be in order that jets of water may be forced from the nipples to a height of 70 ft., with a pressure of 35 lb. per sq. in.? The jets are to be used for washing bottles, and the purpose in having them rise so high is so they will have sufficient force to clean the bottles.

M. H. H., Lowell, Mass.

ANS.—On account of the resistance of air, it would be impossible to make the jets rise to a height of 70 ft. from a $\frac{1}{16}$" nozzle with the pressure you state. If, however, they are properly made, and the main is large enough, the water may be made to flow from them with a velocity nearly equal to that corresponding to a rise of 70 ft. without air resistances. The size of main required depends on its length and the manner in which it is laid. If it is not more than 200 ft. long, and is laid without sharp bends or valves that will obstruct the flow, a 1$\frac{1}{2}$" pipe will be amply large.

***

(371) (*a*) What effect would an increase in the lost motion of the valves of a Worthington duplex pump have on the admission of steam; also what effect would a decrease have? (*b*) Would an ordinary rheostat, such as is used in starting motors, be suitable for a resistance to cut down a 110-volt current to a voltage for charging storage batteries?

J. G. B., New York, N. Y.

ANS.—(*a*) The purpose of the lost motion is to delay the shifting of the valves to such an extent that one piston will nearly complete its stroke before its motion shifts the valve of the opposite side so as to start the other piston on its stroke. An increase in the lost motion would delay the shifting of the valves and cause each piston to begin its stroke relatively later with respect to the motion of the opposite piston. A decrease in the lost motion would have the opposite effect. Increasing the lost motion would also decrease the valve travel and the port opening, while a decrease in the lost motion would increase the valve travel and the port opening. (*b*) Yes; a starting rheostat could be used for this purpose, provided it was divided into enough steps to give the necessary adjustment of charging current. You must also be sure that the rheostat can carry the charging current continuously without overheating. Most starting rheostats are intended to carry the current for a short time only, and if they are used for continuous service, the current must be much less than they are rated for when used as starting boxes.

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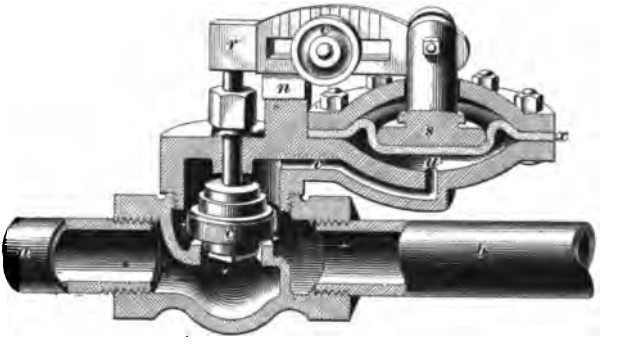
(372) Kindly answer the following questions: (*a*) Is it safe to connect a range boiler to a water-supply system where the pressure is 110 lb.? (*b*) Are there any objections to placing a kitchen boiler in a bathroom located over the kitchen? (*c*) Is it necessary for a soil pipe to be extended through the roof in a case where there is but one closet and one bath connecting with it? (*d*) Will not the ordinary glazed sewer pipe do, in place of cast iron? (*e*) In using cast-iron pipe, will cement do for the joints in place of lead? (*f*) Is a closet less noisy when the tank is placed down near the seat? (*g*) How does the "Case" pressure reducer reduce the pressure when water is not flowing?

O. U. F., Silver Creek, N. Y.

ANS.—(*a*) Yes, provided the waterback and the boiler are made extra heavy and tested to at least 250 lb. hydraulic pressure. (*b*) None whatever that we know of. (*c*) Yes; it should be continued full size, that is, 4 in., up to and through the roof in this case. If the closet were omitted, 2" soil pipe would be large enough; but even this should be continued up to and through the roof. (*d*) Earthenware sewer pipes are only suitable for underground drains, and



even then only when they can be laid on a solid foundation of natural earth or rock. They should never be used for inside work, and should never be laid in ground that has been recently filled in, because they break with the settlement of the ground. (*e*) Some people seem to think that good Portland cement and spun yarn will make a good strong joint on cast-iron pipe, but for house-drainage work we prefer lead, because it is not porous. Cement joints properly made are quite suitable for cast-iron pipes that are filled with hot water, but they are not permitted in house drains by the best informed health departments in the United States. (*f*) Yes. (*g*) We have not had any practical experience with the "Case" pressure reducer, but we have with numerous others. Owing to the fact that all pressure-reducing valves operate on the same principle, the following description should serve your purpose. The accompanying figure shows a pressure-reducing valve of approved make. The pipe *a*, or inlet, connects the valve to the street main or other source of water supply, and *b* connects the valve to the house piping. The disk valve *c* is furnished with a spindle that passes up through a stuffingbox and close-fitting guide, and presses against the end *r* of the lever, whose fulcrum is

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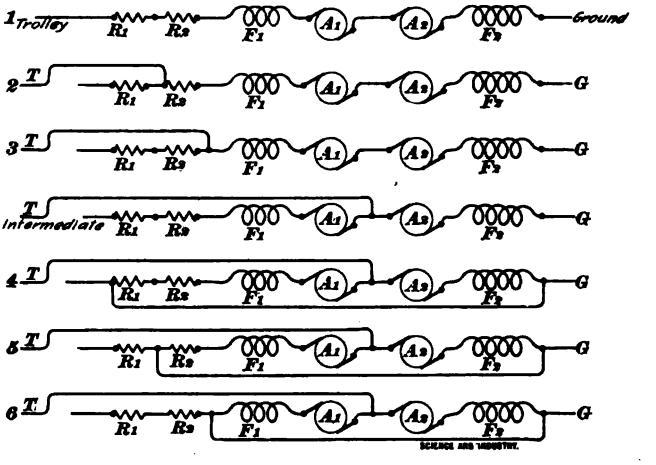
formed by the pin *c*, which passes through a rectangular slot in the casting *n*. The flat disk *s*, which forms the base of a stem or spindle attached to the other end of the lever, sets on a flexible diaphragm *x*, which is held in position by flanges bolted together as shown. A small tube, or waterway, *v* permits water to flow from *b* to the under side of the diaphragm, which is, therefore, subject to the pressure in *b*. Since the total pressure on a given surface is equal to the pressure in pounds per square inch multiplied by the area of the surface in square inches, the total pressure upon a large surface subject to low pressure may be exactly the same as that upon a small surface subject to high pressure. Now, it is evident that if we are required to have a pressure in *b* lower than that in *a*, and to have the apparatus so arranged that the reduced pressure under the diaphragm will close the valve *c* against the higher pressure, the diaphragm area subject to the reduced pressure must be greater than the area of the disk *c*, which is subject to the higher pressure, assuming, of course, that the fulcrum is at or near the center of the lever. Water flows through the valve until the pressure in *b*, or under the diaphragm, reaches that point where the upward pressure on *s* is slightly greater than the upward pressure on the stem of the valve *c*, when the diaphragm will be forced upwards and the valve *c* downwards. This movement will continue as the pressure in *b* increases, until *c* is pressed tightly down on its seat and the valve is closed. When water is drawn from any faucet connected to *b*, the pressure in *b* will decrease and the total force tending to raise *c* being greater than that tending to hold it down, the valve will open and water will flow into *b* until the desired pressure is attained, when the valve will again be closed. Properly constructed pressure-reducing valves are so sensitive in their action that a nearly uniform pressure is maintained in *b*. The valve *c* must be perfectly water-tight when closed, otherwise the pressure in the house pipes, when no water escapes from them, will ultimately reach the pressure of the street mains.

***

(373) (*a*) Kindly describe the action of a controller. (*b*) In what way would you check a calculation for size of feeder when only the drop for a given current has been considered? (*c*) In what way may an alternating current be used in street-railroad work? (*d*) Kindly describe the relative connections of armature, field, and resistance at each point of the Westinghouse controller. (*e*) Give the same for the General Electric controller. W. F., New York.

ANS.—(*a*) A controller consists of a vertical drum on which is mounted a number of contact arcs of copper. This drum is arranged so that it may be revolved about a vertical axis, and contact fingers are fixed so that as the drum is revolved they will come into contact with the metal pieces on the drum and thus effect the various combinations necessary for the control of the car. (*b*) If the drop *E* corresponding to a given current *C* is known, the following formula may be used for obtaining the area of cross-section of the feeder in circular mils. Circular mils $= \frac{14 \times L \times C}{E}$, where *L* = length of feeder in feet. This assumes that the track is well bonded; otherwise the constant 14 would have to be taken larger. (*c*) By using three-phase induction motors, and varying their speed either by means of an adjustable resistance in their armatures or by a method similar to that used for series-parallel control of direct-current motors. Alternating current has been used very little as yet on the cars themselves, the general practice being to change the



alternating current to direct current by means of rotary transformers and then using the ordinary direct-current equipment. Three-phase motors require two trolley wires, which is one objection to their use. (*d*) The accompanying figure shows the various combinations made by the Westinghouse type G controller. Nos. 3 and 6 are the running notches. (*e*) The combinations made by the General Electric K_2 controller are given in the "Steam-Electric Magazine," October, 1899, Answers to Inquiries, No. 213.

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(374) Please advise me what is best to do with an asphalt roof that has cracked and is leaking badly. Can I put Portland cement on top of it, or would it be better to take off the present roof and use fresh asphalt, or would Portland cement be as good? There is 6 in. of concrete underneath the roof coating. J. S., Scarborough, N. Y.

ANS.—It would hardly be advisable to place another covering on top of the old roof, especially of Portland cement, as there would very likely be a difference in expansion and contraction between the two materials, and it would become cracked as badly as ever. You could make an excellent roof by removing the old asphalt and placing on the top of it a 1½" layer of Portland cement and sand. Before placing this layer of cement on the concrete, it would be well to thoroughly moisten the surface of the concrete. We think, however, that possibly a new asphalt roof would answer your purpose better. It is more elastic and will withstand the changes in temperature better than a cement covering.

***

(375) Does a rope suspended between two points describe a parabola? If not, what does it describe? C. B. S., Baltimore, Md.

ANS.—The curve made by the rope is not a parabola, but a catenary. On account of the difficulty attending the use of the catenary when making calculations, the curve is usually assumed to be a parabola; the results thus obtained are sufficiently accurate for practical purposes.

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(376) (*a*) Please explain how to put up a bell in an elevator shaft in a six-story building. There is to be a button for each floor, and the bell is to be run by a battery. (*b*) How could I get a 12″ upright quarter-twist belt to run in center of pulleys 20 ft. apart? Please explain how the pulleys should be lined up. A. M., Chicago, Ill.

ANS.—(*a*) The ordinary method of wiring an elevator bell and annunciator is shown in Fig. 1. This shows four floors only, but the arrangement for six floors is wired in the same way. A single wire *b* is connected to one pole of the battery *B*, and run the whole height of the elevator shaft. One terminal of each push button connects to this common battery wire. Wires are then run from each of the other terminals of the buttons to a point *a* half way up the shaft, where they are connected with a flexible

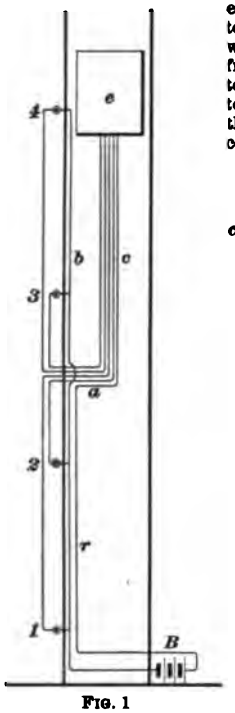

FIG. 1

cable containing one more wire than there are push buttons. In your case you would need a cable with seven wires, as one wire *r* is needed to connect the bell with the other pole of the battery. The other wires connect to the points on the annunciator. You can obtain flexible cable specially suited to this kind of work from any electrical supply house.

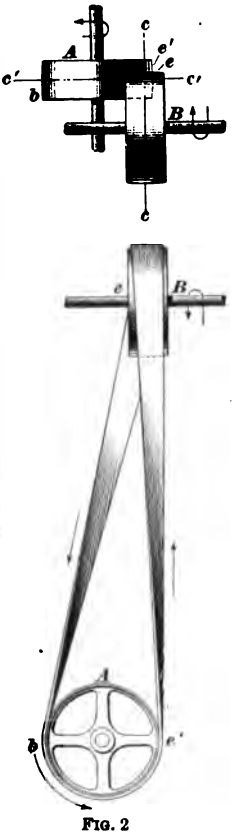

FIG. 2

(*b*) Set the shafts at right angles, as in Fig. 2. The usual rule, and the one always given in books, is to set the pulleys so that the center line *c c* is in the same plane as the face *e'*, and *c' c'* in the same plane as face *e*. This is theoretically correct, but experience shows that it is better to overlap the pulleys more than this, from five-eighths to two-thirds, the width depending largely on the pulley centers. The pulleys can be set by dropping a plumb-line from edge *e* of the top pulley. If one of the shafts is vertical, a straightedge and a spirit level (and string also, if centers are far apart) will be required. In putting on the belt, remember that it must run, for the direction of rotation shown, from side *e* of pulley *B* to side *b* of pulley *A*. The lower view shows this clearly. With this setting of the pulleys, the shaft can only be run one way; otherwise, the belt would not stay on.

***

(377) Kindly give me a good recipe to bring wood to a high polish. W. E. R., Leavenworth, Kan.

ANS.—Your question is rather vague, as there are many methods of producing a high polish on different kinds of wood, some of which are more suitable than others under certain circumstances. The following will be found a simple means of producing the desired result, provided the surface to be polished is not large: If the wood is open-grained, it will be necessary to fill the pores with a filler, which may be obtained ready prepared in any paint store or can be made by mixing chalk or plaster with turpentine until it forms a thick paste. This is rubbed into the grain with a cotton cloth or piece of excelsior, and the wood set aside until it becomes nearly dry. The excess of filler may then be removed from the surface with a sharp steel scraper, and the wood finished with fine sandpaper stretched over a block of wood or piece of cork and rubbed in the direction of the grain. When ready to polish, take a wad of cotton and place it in the center of a piece of cotton cloth about 6 in. square, then saturate it with ordinary shellac varnish. Twist the corners of the cloth together, hold it in the fingers of the right hand, and moisten the outside surface of the rubber thus prepared with a drop of raw linseed oil. Rub this over the surface of the wood slowly in small circular strokes until the entire surface has been covered and the grain seems to be well filled. The wood should then be set aside to dry for about a day, and the process repeated with a fresh cloth and a new rubber. Any tendency of the rubber to stick to the surface of the wood may be overcome by slightly oiling it, although the less oil used the better. This process should be repeated until all the pores are thoroughly filled, and the wood may be scraped or sandpapered between each application if desirable. The final polish is attained by rubbing the surface briskly with a clean cloth moistened with a few drops of alcohol, and the high finish completed by polishing with the bare hand, the latter just before the final varnish rubbing is dry. Should the surface to be polished be too large to be finished in this manner, it may be filled as before and then covered with three or more coats of varnish applied with a flat camel's-hair brush. Each coat must be permitted to dry 24 hours or more and become perfectly hard, when its surface may be smoothed with fine sandpaper, if necessary, before the next coat is applied. The final finishing is then accomplished by rubbing with rottenstone and oil, and afterwards wiping perfectly dry with cotton cloth or cotton waste. A dead finish may be obtained by rubbing the last coat of varnish with powdered pumice stone and oil or with pumice stone and water, instead of the rottenstone. In selecting varnish for this purpose, a rubbing varnish must be used, as any soft varnish would peel up in the rubbing.

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(378) Please inform me what coefficient of friction to allow for water flowing through a pipe made of plate iron similar to a boiler shell. The length of pipe is 27 ft., the diameter 28½ in., and the head 11 ft. T. T. D., Wallingford, Conn.

ANS.—The experimental data on which to base a coefficient for a pipe of this construction, under the conditions named, are very meager. The following method will, perhaps, give as satisfactory results as any: For such a short pipe, one of the principal

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resistances is that due to the contraction of the stream at the entrance to the pipe. For a pipe whose end is nearly flush with the surface of the reservoir from which it leads, the entrance head may be taken as one-half the velocity head x. The entrance head and velocity head are then equal to $x + \frac{1}{2}x = \frac{3}{2}x$. Calling the friction head y, the total head 11 ft. is equal to the sum of the velocity head and of the head due to the resistances, giving us the equation, $\frac{3x}{2} + y = 11$. According to the law of falling bodies, the relation between the velocity of flow v and the velocity head x is $x = \frac{v^2}{2g}$. Adding the entrance and velocity heads, the sum is $\frac{3v^2}{4g}$. Assuming the friction for this pipe to be the same as for a new cast-iron pipe of the same diameter, the velocity of flow is given by the formula $v = 1.78\sqrt{\frac{1{,}000\,D\,y}{L}}$, in which D = diameter, and L = length of the pipe, both in feet. Substituting, we have $v = 1.78\sqrt{\frac{1{,}000 \times 28\frac{1}{4} \times y}{12 \times 27}}$, from which $y = \frac{v^2}{273.8}$. Substituting now in the equation for the total head, we have $\frac{3\,v^2}{4 \times 32.16} + \frac{v^2}{273.8} = 11$, from which the velocity of flow is $v =$ 20 ft. per sec., nearly.

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(379) (*a*) How can I determine the electromotive force and current induced in a medical induction coil whose core is ⅜ in. in diameter and 3½ in. long? The primary is wound with 96 turns of No. 16 B. & S., and the secondary with 1,800 turns of No. 28 B. & S. One cell of battery is used. (*b*) In the coil above described, suppose the core were made ¼ in. in diameter and 4½ in. long; would the induced electromotive force be higher in this coil than in the other? (*c*) How are current regulators made for induction coils? Do they regulate the exciting current only, or do they regulate the current from the secondary? (*d*) I have a coil made according to dimensions given in (*a*), but it is too strong, even when used with only one dry cell. Please state a method for regulating it. A. S. L., Anneta, Tex.

ANS.—(*a*) It is a very difficult matter to estimate the electromotive force induced in the secondary of an induction coil with any degree of accuracy, because it depends not only on the windings and strength of the battery, but also, to a very large extent, on the character of the break. For example, a coil equipped with a poor contact-breaker might give a very much lower E. M. F. than the same coil equipped with a breaker giving a very sharp break. In large coils, the E. M. F. can be estimated from the sparking distance. For a small coil, the best method would be to use an electrostatic voltmeter. (*b*) If the number of turns were kept the same in both cases, the E. M. F. would be increased to some extent. (*c*) The current from the secondary may be regulated in a number of ways: (1) by inserting adjustable resistance in the primary; (2) by splitting the secondary up into a number of sections that may be cut in or out by means of a switch; (3) by winding the secondary on a separate spool arranged so that it may be slipped on or off the primary; (4) by connecting a very high resistance across the secondary terminals, as, for example, a graphite resistance, and then connecting the patient to one terminal and moving the other electrode terminal along the resistance until the required strength is obtained. (*d*) You can use any of the above methods for regulating your coil, but the first one would probably be the easiest to apply.

(380) If we have one end of a pipe attached to the bottom of a boiler shell, at a point 2 ft. below the surface of the water, and the other end attached to the top of the shell so as to communicate with the steam space, what will be the difference in pressure at the two ends of the pipe? Does not the water increase the pressure at the bottom over the pressure of the steam at the top? F. C. S., Lonaconing, Md.

ANS.—The pressure per square inch at the bottom connection will be as much greater than the steam pressure as the weight of a column of water 1 in. square and as high as the vertical depth of the water above the connection. The weight of a column of water 1 in. square and 1 ft. high is very nearly .434 lb. at ordinary temperatures; the increase in pressure for a depth of 2 ft. is therefore very nearly $2 \times .434 = .868$ lb. An accurate gauge attached at the bottom connection of the boiler would show a pressure of about .868 lb. per sq. in. more than it would show if attached to the steam space.

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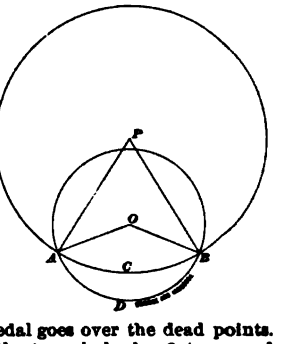
(381) (*a*) Is there any more power received by the use of Ramsey's bicycle pedal than by the use of the ordinary kind? If so, explain why. (*b*) How do you find the area of a crescent?

W. C., Worcester, Mass.

ANS.—(*a*) Some bicycle riders think a pedal of this kind enables them to climb hills easier than with the ordinary type of pedal. It does not increase the power, but it may enable the rider to exert himself to better advantage while climbing a hill. Any advantage it may have is in enabling the rider to exert a more constant turning force on the crank and so prevent the loss of turning effect that takes place as the pedal goes over the dead points. (*b*) Let the radii of the two circles be $OA = r$ and $PA = s$. Let the number of degrees in the central angle AOB be $2m$, and let the number of degrees in the central angle APB be $2n$. Let π denote the ratio of a circumference to its diameter; so that $\pi = 3.1416$, nearly. Then the area S of the crescent $ACBD$ is given by the formula



$$S = r^2\left(\frac{m\,\pi}{180} - \tfrac{1}{2}\sin 2m^0\right) - s^2\left(\frac{n\,\pi}{180} - \tfrac{1}{2}\sin 2n^0\right).$$

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(382) (*a*) What would be the effect on the earth if the moon were taken away? (*b*) What would be the effect on the ocean? Would its motion cease?

J. M. G., Mexico.

ANS.—(*a*) The only effect on the earth proper would be a total darkness of that portion not illuminated by the sun: in other words, moonlight would be a thing of the past, much to the discomfort of the inhabitants of high latitudes, whose supply of natural light, during the several weeks of short days prevailing in those regions, depends on the moon. (*b*) We do not know to what motion of the ocean you refer. The principal motions of the ocean are currents and tidal streams. Ocean currents are caused by the ever-changing temperature, and are therefore indirectly influenced by the sun; the absence of the moon would have very slight or no effect on this kind of motion of the ocean. Tidal streams and tides are caused by the combined direct action of the sun and moon, these two bodies producing two different classes of tides, viz., solar tides

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and lunar tides. We know that at the time of conjunction the moon and sun attract the water in the same direction, and therefore the tides are then equal to the sum of the lunar and solar tides. The same is true at opposition, because each attracting body produces two tides at once, and the direct lunar tide coincides with the opposite solar tide, and vice versa. These, we know, are the spring tides that occur at the syzygies. At quadrature, each body raises a tide at the expense of that raised by the other. From this, it is evident that should the moon be removed or her influence be reduced to nil, the lunar tides would disappear but the solar tides would continue to exist. On account of the distance of the sun being so great, however, the solar tides are of less magnitude and importance, and, consequently, a radical change would take place in respect to prevailing tides. Other agencies would then have to be set in motion in order to perform the present function of the tides, viz., to prevent the sea from becoming stagnant by distributing in all directions the salt that the ocean contains.

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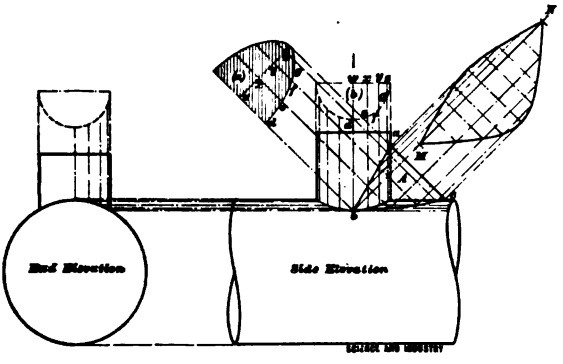
(383) The accompanying drawing shows a side and an end elevation of an intersection between a boiler and smokestack. Please explain a method for developing the pattern for the gusset plate marked *A*. K. W., Pottstown, Pa.

ANS.—In the drawing sent to us by this correspondent, the line *b c* of the side elevation was represented



as a straight line; it should properly have been an irregular curve, since the line represents the intersection of an irregular solid whose form is such that it may miter with the stack along the line *a b*. The accompanying illustration shows how the correct curve is produced, regular methods of projection from the end elevation being employed in the manner shown. Having determined the outline of the curve *b c*, projectors are thence carried indefinitely upwards and parallel to *a c*, and at (*a*) the required sectional view is constructed. A comparison of the view at (*a*) with that shown at (*b*) will enable the reader to understand the method of constructing the section, since equal spaces in the different views are denoted by similar letters. After drawing the sectional view at (*a*), the stretchout *M N* is laid off at right angles to *a c*, and the spaces on *M N* are made equal to those on the outline of the section. Parallels to *a c* are drawn through the points thus located, and the development is then completed by drawing lines parallel to *M N* from the extremities of the lines on the gusset plate.

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(384) (*a*) What is the ratio between the sizes and number of turns on 110-, 220-, and 500-volt motors, other things remaining the same? (*b*) If a 500-volt motor has on its armature 24 slots, 105 turns per slot, No. 17 wire, and 11,500 turns No. 27 on the fields, what would it have if it were wound for 110 and 220 volts? This is a 3 H. P. Crocker-Wheeler machine. Would the ratios hold good for other machines? (*c*) Can I use a compressed-air engine to any advantage in an automobile? If so, where can I get some information relating to such engines?

F. V. Y., St. Louis, Mo.

ANS.—(*a*) If *A* is the cross-section in circular mils of the wire on the 110-volt motor, then that on the 220-volt machine will be $\frac{A}{2}$, and on the 500-volt motor about $\frac{A}{4.5}$. If *T* is the number of turns on the 110-volt motor, then 2 *T* will be the number on the 220-volt motor, and 4.5 *T* the number on the 500-volt motor, nearly. If *R* is the field resistance of the 110-volt motor, then the field resistance of the 220-volt motor will be 4 *R*, and that of the 500-volt motor 20.6 *R*, nearly. Of course, it is impossible, in practice, to select sizes of wire and number of turns to exactly satisfy these proportions, but they can usually be approximated so that the machine will give the right voltage with but a slight change in speed. These ratios hold for any machine. (*b*) No. 17 wire has a cross-section of 2,048 circular mils; hence, the required cross-section for 110 volts would be $2{,}048 \times 4.5 = 9{,}216$. This lies between No. 10 and No. 11. The number of conductors per slot would be $\frac{105}{4.5} = 23+$. Since you would not need so much room for insulation, you could probably get on about 24 turns of No. 10 per coil. For 220 volts, the required cross-section would be $\frac{9{,}216}{2} = 4{,}608$, or a No. 14 B. & S. The conductors per slot would be about 46 or 48, i. e., twice as many as for the 110-volt machine. With regard to the field winding, the 110-volt machine should have, approximately, $\frac{11{,}500}{4.5} = 2{,}555$ turns. The cross-section of No. 27 is 201 circular mils; hence, for the 110-volt machine, the cross-section should be 904.5, or about No. 20. For the 220-volt machine, the cross-section would be $\frac{904.5}{2} = 452$ circular mils, or about No. 24 B. & S. For the 220-volt machine, there would be about $2{,}555 \times 2 = 5{,}110$ turns on the field. Like the armature windings, it is never possible to make the field windings come out exactly. The aim should be to make the resistances about in the proportion given in (*a*), so that the watts lost in the field will be nearly the same in each case. (*c*) There is no data on the subject of the application of compressed air to automobile purposes now available that seems to indicate that it can be made to compete successfully with either gasoline, steam, or electricity. Nothing has yet been published that will give you any practical information on the subject.

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(385) The accompanying sketch represents a closed tank in which there is water to the depth of, say, 2 in. In one head is an inlet for steam at a pressure of 7 lb. per sq. in., and in the other head an outlet formed by the bent piece of pipe, one end of which extends below the water-line. (*a*) Kindly explain what causes the steam to drive the water out through the bent pipe. (*b*) How can the depth below the end of the pipe from which the water will be forced out through the bent pipe, when the water-line falls below the end, be calculated? (*c*) If a hole should be cut in the bent pipe at *A* with a diameter equal to the inside diameter of the pipe, would the action be

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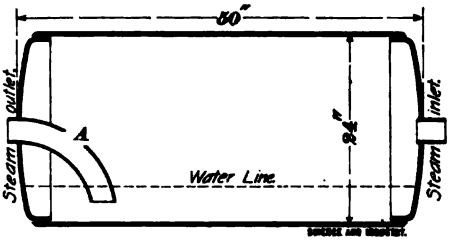
any different, and if so, what would the action be? (*d*) Would the tank be emptied any more rapidly with the hole cut in the pipe than it would without, and if so, what rule may be used to calculate the most efficient size of hole? (*e*) Why is an alternating current more economical than a direct current, and why can it not be used to drive a direct-current



motor? (*f*) Please name some books in which I can get information on above questions.

H. W. B., Philadelphia, Pa.

ANS.—(*a*) The water would be forced out through the pipe merely by the action of the pressure of the steam on its surface. (*b*) There is no rule by means of which such a calculation can be made. (*c*) With a hole cut as you suggest, it is probable that no water would be drawn from the tank, but by inserting a nozzle so as to make a device something like an injector, water might be drawn up through the bent tube by the outflowing current of steam. (*d*) No. (*e*) The principal advantage of the alternating current is that by its use high-voltage currents are practicable, thus making it possible to use smaller wires for transmitting the current without a serious loss. A satisfactory explanation of the relation between alternating- and direct-current motors would take more space than is available in these columns. (*f*) For an explanation of the principles involved in the action of the steam in forcing water out of the tank we would recommend "Avery's Natural Philosophy," price $1.15. This book also contains much useful information about electricity. For the special information about alternating currents and motors for which you ask, we would recommend "Elementary Lessons in Electricity," by Sylvanus P. Thompson, price $1.40. The above books may be obtained from The Technical Supply Co., Scranton, Pa.

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(386) (*a*) In a two-cycle gasoline engine with a 3″ × 3″ cylinder, an enclosed crank-chamber, and the ports opened and closed by the motion of the piston, will a ¾″ pipe do for the admission port and a ½″ pipe for the exhaust, these pipes being tapped into the cylinder instead of having the ports cored in? (*b*) If the exhaust port is half open when the admission port begins to open, will the engine work well? (*c*) What should be the weight of the flywheel if its diameter is about 11 in., the number of revolutions 300 per min., and the compression about 55#? (*d*) Give me some suggestions in regard to the arrangement of the igniter points in the cylinder and for making the upward motion of the pump guide work the sparking device. N. H. R., Philadelphia, Pa.

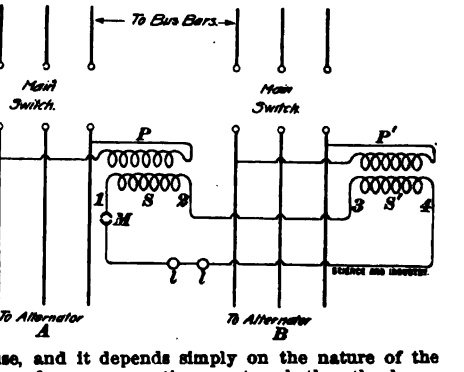
ANS.—(*a*) If the engine is not to run more than 300 R. P. M., ports of the dimensions you name would be large enough; if it is to run at higher speeds, they should be somewhat larger. We would prefer to make the ports by coring openings in the cylinder, making the dimensions of these openings about ¾ in. wide by 2 in. long (measured around the circumference of the cylinder) for the admission port, and about $\frac{7}{8}$ in. by 2 in. for the exhaust port. (*b*) With the dimensions we have suggested, the plan you propose will work well. (*c*) The size and weight of flywheel required depend on the permissible variations in speed. With a diameter of only 11 in., it will be difficult to make a wheel heavy enough to give satisfactory results at a speed of 300 R. P. M. By making the wheel 24 in. in diameter, moderately good results for ordinary work can be obtained with a weight of rim of 60 lb. For work like electric lighting, requiring close regulation, a larger or heavier rim would be required. For a given degree of regulation or steadiness of motion, the weight of rim required is inversely as the square of the diameter and the cube of the number of revolutions per minute; consequently, an increase in these factors increases the effect of the wheel much faster than does an increase in the weight of the rim. (*d*) It is impracticable in the space here available to give you any suggestions of value regarding these points.

***

(387) Show how the synchronizing devices used when placing alternators in parallel are arranged. Give connections for three-phase system, and explain principle of operation. Explain how some are in phase on a bright light, and some with lamp out.

C. F. K., Redlands, Cal.

ANS.—The accompanying figure shows the common arrangement of synchronizing lamps for three-phase machines. *P S*, *P′ S′* are the primary and secondary coils of two small transformers. Generally, the ordinary type of potential transformer used with alternating-current voltmeters is employed for the purpose. The primaries *P* and *P′* are connected to corresponding phases of the two machines, as indicated. The two secondary coils *S* and *S′* are connected in series through the lamps *l*, *l* and the synchronizing plug inserted at *M*. From the way in which the transformers are connected, it will be seen that terminals *1* and *3* will be of the same polarity at any given instant when the machines are exactly in synchronism, i. e., when terminal *1* is +, terminal *2* is —, terminal *3* is +, and terminal *4* is —. When, therefore, the plug *M* is inserted and the machines are in step, the pressures of the two secondaries connected in series will be added together, and the lamps will glow. Suppose, however, that the connections of *P* are reversed, or, what amounts to the same thing, suppose either of the secondaries to be reversed from the connections shown. The electromotive forces of the two secondaries will then oppose each other, and the lamps will be dark when the machines are in step, and will be bright when they are opposite in phase. Both schemes are in



use, and it depends simply on the nature of the transformer connections as to whether the lamps will be light or dark when the condition of synchronism is attained. When the machines are first installed, it is necessary to use two-phasing transformers for each machine in order to make sure that the transformers to be used permanently are connected to corresponding phases. After this has been

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determined, the temporary transformers may be dispensed with, and only one used for each machine, as indicated.

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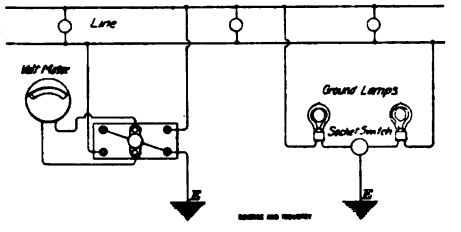
(388) (*a*) The accompanying sketch shows two ground detectors on different parts of a circuit. When both switches are closed on opposite lines, is there not a short circuit? (*b*) When we get a ground on the light circuit and also a ground on one of the electric cranes, we cannot run the crane with safety. Where does this differ from the case given in (*a*)? (*c*) We use Bagnall arc lamps in series for street lighting. When one of them jumps, owing to improper resistance, why do not all the lamps on the circuit do the same? Is the circuit not broken each



time the arc jumps? (*d*) Please give a diagram of connections for a Keystone desk telephone.

W. J. C., Pittsburg, Pa.

ANS.—(*a* and *b*) In the first case, there is no short circuit. The term "short circuit" carries with it the idea of a short path for the current, this short path *having very little resistance*. In the case of ground detectors, the current has to pass through the lamp and voltmeter, both of which have a high resistance. This high resistance limits the current so that no bad effects are noticed. In the second case, there is no such high resistance in series with your grounds, and the result is that when both grounds are present, the electromotive force is able to set up a very large current, which is liable to do damage. (*c*) If a number of lamps are run in series, the fluctuations in current caused by one lamp jumping are not sufficient to make the other lamps jump. The total voltage generated by the dynamo is very high in the case of a series-arc system, and the fluctuations in voltage across any one lamp would be but a small percentage of the whole, and the resulting fluctuations in current would be correspondingly small. Jumping does not usually open the circuit. Series lamps are, however, provided with an automatic cut-out so that, if the arc does become broken, the circuit will be maintained. (*d*) We do not have the diagram of connections for this desk telephone.

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(389) (*a*) Could a cream separator be run by a motor with the armature mounted directly on the spindle? The spindle runs 8,000 R. P. M. (*b*) Would it require a higher voltage to run a motor at such a high speed than at a low speed, and if so, why? (*c*) What is the meaning of the terms "undercompounded" and "overcompounded" when applied to a dynamo? (*d*) A plank is 12 ft. long and weighs 24 lb. It is supported by two props, one of which is 1 ft. from one end, and the other 3 ft. from the other end. How much weight does each prop support?

H. C. L., Hyde, Assa.

ANS.—(*a*) It would hardly be possible to make a motor to operate satisfactorily at as high a speed as 8,000 R. P. M. You had better run the motor at a lower speed and use belting. (*b*) The speed of a motor depends on the strength of its field, the voltage of the supply, and the number of conductors on the armature. For very low voltages, there would likely be difficulty in making a motor run well at the high speed you name. However, if it were not for mechanical limitations, a motor could probably be built to run at the above speed on any one of the common voltages, i. e., 110, 220, or 500 volts. (*c*) A dynamo is said to be "overcompounded" when the series coils are sufficiently powerful to cause the voltage to rise as the load increases. The term "undercompounded" is not used very frequently, but it would be applied to a compound-wound dynamo, the series coils of which were not powerful enough to hold up the voltage with increasing load. (*d*) The weight on the prop 1 ft. from the end would be 9 lb.; that on the other prop would be 15 lb.

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(390) Kindly give the correct answer to the formula $E\sqrt{1+\left(\frac{x}{r}\right)^2}$, in which $E = 1{,}000$, $r = 90$, $x = 100$.

J. B., Central Falls, R. I.

ANS.—Substituting the known values for the letters, we have $1{,}000\sqrt{1+\left(\frac{90}{100}\right)^2}$. As $\frac{90}{100} = .9$, we have, after squaring .9 and adding it to 1, $1{,}000\sqrt{1.81}$. Extracting the square root of 1.81 and multiplying by the 1,000, the result is 1,345.4, which is the value of the given expression.

***

(391) We have in operation a dry kiln for drying oak lumber that has been sawed 6 months or longer. It takes from 12 to 14 days to dry the lumber. The kiln is 18 ft. long, 12 ft. wide, and 10 ft. high, inside measurements. It has an air space of 8 in. in the outside walls, which are made of two 1" boards, with heavy building paper between them, and the ceiling is made of the same material. The heating coil is composed of 1,416 ft. of 1" pipe that returns the whole length of the kiln. The steam main is 4 in. I keep the temperature at 100° for the first 3 days, and then at 130°. If I raise the temperature above this, it checks the lumber; there is no circulation of air in the kiln. How can I dry lumber more quickly, and, if I need a circulation, how can it be accomplished? I also have a 1" pipe that projects in the top of the kiln by which I turn steam in the kiln for an hour every morning. Is this a good plan? I would like to hear from some of the readers of SCIENCE AND INDUSTRY who have had considerable experience in dry kilns.

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ANS.—In "Home Study for the Building Trades," December, 1898, page 108, you will find a description and drawings of a small lumber kiln, heated and ventilated, that appears to suit your case. The process of blowing steam into the kiln every morning is considered by many to be an excellent means of preventing oak from becoming checked. We will be pleased to receive suggestions from practical men in the lumber business for the benefit of our correspondent.

***

(392) Please tell me how to find the length of the piston rod of a vertical engine, the connecting-rod being finished.

H. C. P., San Francisco, Cal.

ANS.—We take it for granted that the engine is all built with the exception of the piston rod and that it is desired to find the correct length to make the rod. Under these conditions we would advise the following method: Connect up the crank, connecting-rod, and crosshead, and put the crank on its upper, or head, center. Measure the distance from some point on the crosshead from which a corresponding point on the piston rod can be conveniently located to the inner surface of the upper cylinder head. From this measurement, subtract the piston clearance; the remainder will be the length of the piston rod from the point chosen on the crosshead to the upper surface of the piston. By adding to this length the amounts required for connection to crosshead and piston, the total length of rod will be found. As a check, it would be well to make a similar measurement from the point on the crosshead to the upper surface of the lower cylinder head when the crank is

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on its lower center. The piston clearance plus the thickness of the piston added to this measurement, should give the same length as was obtained when the piston clearance was subtracted from the first measurement.

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(393) I wish to put in a fan for the purpose of carrying the dust and shavings from wood-turning machinery to the boiler room. The shavings are coarse, like excelsior. The distance is from 80 to 100 ft. in a straight line, size of pipe 8 in. (*a*) Where should the fan be placed to give the best results without having the shavings go through it? (*b*) What type of fan is adapted for this work? (*c*) How may I calculate the size? (*d*) Please give me instructions for installing the piping for heating a four-story factory 130 ft. × 35 ft., ceilings 15 ft. high, with the exhaust from a 30 H. P. Corliss engine. If possible, furnish a diagram of arrangement, giving size and length of coils. There are no partitions on either floor. (*e*) I have a quantity of No. 30 covered copper wire with which I wish to make a voltmeter to work on a 110-volt alternating circuit. What is the most practical instrument I could make to serve my purpose? E. W. B., Rock Island, Quebec.

ANS.—(*a*) We do not know of any method of installing a fan for such a purpose that does not make it necessary for the shavings to pass through the fan. By constructing the blades in such a manner that there will be no corners or projections on which the shavings can catch, they will pass through the fan without causing trouble. Fans for handling the straw from thrashers are constructed in such a manner, and work successfully without clogging. (*b* and *c*) It is impossible in the space available in these columns to describe a fan that would serve your purpose or the methods by means of which its dimensions could be calculated. We would advise you to purchase a fan from some maker that has had experience in work of that kind. The B. F. Sturtevant Co., Boston, Mass., The Buffalo Forge Co., Buffalo, N. Y., or The American Blower Co., Detroit, Mich., can furnish a fan that will serve your purpose much better than one you can make. (*d*) It is impossible to give you a diagram or to give definite dimensions for the various parts of your system without knowing more of the conditions than you have stated. The following general principles should, however, enable you to install a satisfactory system for yourself: The distributing pipes should be large, so as to carry the steam freely and not put a heavy back pressure on the engine. A direct connection to the boilers through a pressure-reducing valve should be made, so as to supply steam to the system automatically when the engine is stopped. A relief or back-pressure valve should be placed on the exhaust pipe, to permit any surplus exhaust to escape. Provision should be made to drain the water and oil from the exhaust so that it cannot get into the distribution and radiating pipes. The amount of radiating surface usually required for shops is 1 sq. ft. for each 100 cu. ft. of space to be heated. If your shop is in an exposed location, or the walls are thin and have many windows, it will be well to make the radiating surface somewhat greater. (*e*) About the simplest instrument to make for this purpose would be one in which a coil or solenoid is mounted vertically and arranged so as to draw an iron core into it. Make the coil about 5 in. long and 1½ in. outside diameter, with a ¾" hole through the center. Make the core of a bundle of soft-iron wires made up to form a core ¾ in. in diameter. Suspend this core from a small beam mounted on knife edges, so that, when the hand is at zero, the core will be slightly inside the end of the coil. Arrange an adjustable counterweight so as to control the movement of the needle, and attach the pointer to the beam so that it will play over the scale when the iron core is drawn into the coil. If you wish to leave this voltmeter in circuit continuously, it will have to be of high resistance, otherwise it will overheat. If you simply wind the coil with copper wire and connect no external resistance in series with it, you should arrange a key so that the voltmeter may be cut out when not in use.

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(394) (*a*) What is osmium, and where is it found? (*b*) What is it used for, and where can it be bought? (*c*) What metal is in the human skeleton, and how is it extracted? P. K., New York, N. Y.

ANS.—(*a*) Osmium is a rare metal that is found, together with platinum and some other rare metals, in California, Russia, Brazil, Australia, and Peru. (*b*) The metal itself has no use, but an alloy is used for tipping gold pens and for compass bearings. It can be obtained from any chemical supply house. (*c*) Calcium is the chief metal occurring in the human skeleton. This alkaline earth is so plentiful everywhere that it is not extracted from the bones.

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(395) I have four ceiling fans of standard make designed to be put four in series on a 500-volt circuit. Each fan requires about .75 ampere and has two wooden blades, each about 2 ft. long. Why is it that the speed of each fan is not the same? They have been cleaned and repaired each season, but this season, after repairs, one of the fans runs very slow. The speed of the other three is about right. From inquiries and what I have noticed elsewhere, this seems to be a common fault of ceiling fans when run in series. W. H. H., Jersey City, N. J.

ANS.—Motors operated in this way on constant-potential mains are in an unstable condition and are liable to give the trouble you mention. Since the motors are in series, the current in all four is the same, and, if they are exactly the same in design, the torque or twisting effort exerted by each will be the same. If their loads are all exactly alike, they will be in equilibrium and will run at the same speed. If, however, from some cause or other, say a slight increase in friction, the load on one becomes greater than that on the others, it will slow down some, thus lowering its counter E. M. F., throwing more pressure across the remaining motors, and increasing their speed. If the motors are to run at the same speed, they must all be kept in the same condition, and even then the speeds are liable to change more or less, because it is hard to avoid small inequalities of load. The only way to make such motors connected in this manner act stable, is to have them all coupled together, which is not possible in the case of fan motors. You might examine the faulty motor and see whether there is any undue friction about it or whether its blades are set at the same angle as the others. Perhaps by setting its blades at a slightly smaller angle, you will be able to bring up its speed. The above assumes, of course, that the windings of the motor are in good condition.

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(396) If two balls made of the same material are dropped at the same instant from the same height, which will strike the ground first, one ball weighing 1 lb. and the other 100 lb.?

H. B. F., Jersey City, N. J.

ANS.—Neglecting the resistance of the air, both will strike at the same instant. For, consider 100 1-lb. balls to be made from the 100-lb. ball; if all are dropped at the same instant, all will strike at the same instant. The same would be true if all the balls were fastened together, or if they were all cast in one 100-lb. ball.

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SCIENCE AND INDUSTRY

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A VISIT TO NANKING, CHINA

Lieut. Charles A. Foster, U. S. N.

NOTES FROM THE LOG OF A NAVAL OFFICER—A CITY FOUNDED 7,000 YEARS AGO—THE PORCELAIN TOWER AND THE ARSENAL

EARLY in the month of February, 1890, the U. S. S. Monocacy, Commander M. L. Johnson commanding, in obedience to orders from Rear-Admiral Geo. E. Belknap, our commander-in-chief, proceeded from Chinkiang to Nanking in order to make an official visit to the celebrated Tseng-Kwo-Chuan, Viceroy of the two provinces of Kiang-Su and Au-Whei, and urge him to settle the claims of American missionaries at that place for damages committed by a Chinese mob to mission property. Gen. A. C. Jones, the United States consul at Chinkiang; Père Chevalier, the head of the Jesuit missions on the Yang-tse-Kiang; and Mr. Wan Bing Chung, a very intelligent Chinese gentleman who had been educated at Worcester, Mass., and acted as interpreter to the U. S. Consulate at Chinkiang, accompanied us.

We steamed up the Yang-tse-Kiang, passing numerous junks and river craft. The banks of the river were covered with a thick growth of tall reeds, which were being cut and stacked for use as fuel. At times we passed through reaches black with wild fowl, principally geese, teal, and mallards. The birds seemed fat and lazy, and, as we came along, appeared to rise only from compulsion, in heavy clouds, the beating of their wings being like the sound of distant thunder. We amused ourselves by giving several short sharp blasts with the steam whistle, which would cause them to rise vertically upward for a height of several hundred feet. Early that evening we moored the ship a short distance below the ancient city of Nanking.

Nanking is situated on the right bank of the Yang-tse-Kiang River, 44 miles above Chinkiang, 198 miles from Shanghai, and 230 miles from the sea. Until the commencement of the 15th century, it was the metropolis and capital of the Chinese Empire, for which, from its position, it was eminently adapted. Its history is lost in the dim twilight of the past. First occupied by a wild tribe, it beheld eight dynasties pass away. According to Chinese chronology, its birth took place 7,000 years ago, and it had at one time 4,000,000 inhabitants. The remains of its ancient wall can be traced for 35 miles in circumference, testifying to its former magnificence. The present city is surrounded by a wall of irregular shape, 17 miles in circuit. This wall is, in places, from 50 to 70 feet in height and 30 feet in thickness at the base. All but six of its seventeen gates have been walled up. There is much waste land within the city, the inhabited portion lying toward the east, some 4 miles from the river.

On the removal of the capital to Peking by the Manchus, Nanking lost its prestige and began to decline, although its monuments, libraries, and institutions of learning, together with its commerce and manufactures, made it an important city. It was stormed by the Taepings, March 19, 1853, and the city was held by them until the "ever victorious army," under "Chinese Gordon," of Khartum fame, crushed the Taepings in their outlying strongholds and joined the imperial army under the celebrated Viceroy Tseng-Kwo-Fan. They carried it by assault, July 19, 1864. On its recapture, it was converted to its former position as the seat of the viceregal government.

The Taepings destroyed many of its ancient monuments, among them the celebrated porcelain tower, or pagoda. The city has far from recovered from so many years of

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strife and bloodshed. Its principal manufactures are satin and velvet. The manufacture of the so-called "nankeen," which made the name of the city so famous all over the world, has almost altogether ceased.

At 8 o'clock in the morning after our arrival, we saluted the Chinese flag with twenty-one guns and His Excellency, the Viceroy, with seventeen guns, the salutes being returned from the fort on shore. Shortly afterward a mandarin with a small gunboat was sent by the Viceroy to convey the consul and the captain and his officers to the city. The party, of which I was a member, left the ship at 10 A. M., the consul being saluted with nine guns as we left the vessel. The gunboat was a small affair, manned by soldiers and armed with a small gun in the bow. It had a poop cabin for the accommodation of officials, and was of the class frequently met with on the Yang-tse-Kiang, and used as river guards. The party having landed, proceeded to the French mission, where we had luncheon, and then called on the Taotai, or governor of the city, and arranged with him for an audience with the Viceroy at 10 o'clock the next day.

The long distances to be traversed and the time required to make official visits made it almost a necessity to remain on shore over night, and the fact that there were no public accommodations made this very inconvenient. We were relieved from this dilemma, without any solicitation on our part, through the kindness of the Fathers of the French mission, who placed their domicile at our disposal, we becoming the recipients of their generous hospitality during our stay in Nanking. Their present mission house occupies the same ground as that first granted to Père Ricci, S. J., some 250 years ago.

The following morning, February 5, General Jones, Captain Johnson, and the officers of our party, accompanied by Père Chevalier and Mr. Wan, left the mission in covered sedan chairs, escorted by a dignified-looking mandarin and a guard of Chinese soldiers. Chinese etiquette requires all ceremonial visits to be made in sedan chairs; to go in any other way would be to lose caste —in fact, visitors so going would not be received. Everywhere along our route we saw the evidence of extreme misery and destitution. On arriving in front of the gates of the palace, we were detained for a few moments and soon found ourselves the center of attraction for a curious crowd of the poorer class of Chinese who had gathered to see the "foreign devils." The gates being thrown open, we were carried into the outer court, where we left our chairs, and were conducted through a succession of courts to the inner one, where we were received by the Taotai Lin, who ushered us into the presence of Tseng-Kwo-Chuan, Viceroy of the provinces of Kiang-Su and Au-Whei.

The Viceroy is a member of the celebrated family of Tseng. He is a brother of the conqueror of Nanking, and also of Viceroy Tseng-Kwo-Fan; his nephew was the late Marquis Tseng, at one time the Chinese ambassador to England. Himself a distinguished soldier, he held a command under his brother, the Viceroy Tseng-Kwo-Fan, and led the assault in person which led to the fall of Nanking; but, according to Chinese etiquette, his elder brother received the honors won by the younger, who at the time of our visit was suffering from wounds received at that time. After the usual interchange of compliments, the Viceroy invited us to partake of a breakfast prepared for us in his summer pavilion at the Mok Chau Lake, requesting that we should excuse his presence on account of ill health and saying that his friend the Taotai Lin would represent him at the entertainment. The audience then ended and we withdrew.

Entering our chairs, we left the palace and were escorted to the pavilion, our way lying through dirty narrow streets, thronged by crowds of miserable beggars of all ages. Many of them were so ragged that it seemed a miracle that their rags held together. As we neared our destination, their numbers increased until we arrived at the gates of the pavilion grounds, where a multitude of some thousands of these poor wretches were assembled and were kept within bounds by the soldiery.

We learned that the "Viceroy's poor" were gathered in camp along the banks of the lake. To relieve their necessities, the Viceroy issued rice tickets to 130,000 poor every five days. I was informed that in many cases the very poorest people were not so favored, as some of the officers appointed to inquire into their condition and take the census of those requiring assistance, took the names of those only who were able to pay something for the accommodation. The poor were to be subsisted until April or May and then turned out to shift for themselves. These people did not, for the most part, belong to the province of the viceroyalty, but numbers of them had swarmed in from the now barren districts of the Yellow

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River, made desolate by its fearful inundation. The poor, as stated by Taotai Lin, "came and gathered like the birds of the air." With such harrowing sights to be met with in the Chinese Empire, it is no wonder that wild rumors fly about predicting the downfall of the present dynasty.

The Viceroy's pavilion is pleasantly situated, its spacious verandas overlooking the lotus-covered waters of the Mok Chau Lake, so called after a famous beauty who flourished some centuries ago. Her name, Mok Chau, means "no sorrow."

The Taotai Lin, Tso-Yu, is the lifelong friend of the Viceroy Tseng, and is somewhat of a Poo-Bah, holding eight different offices, among them that of General Chief Secretary of Foreign Affairs, and Immediate Expectant Taotai of the Second Rank. He was a shrewd fine-looking man, seemingly much younger than his 67 years would warrant. His manners were agreeable, and his hearty laugh and genial manners bespoke good fellowship. He wore an elegant sable robe, and around his neck was a magnificent necklace of coral, amber, and jade beads of large size. He was well read, and in conversation expressed his admiration for the military genius of Napoleon and Washington. The Taotai has had five wives without being a polygamist, and is the father of nine sons and nine daughters, all of whom are living. The courses consisted of the usual Chinese delicacies, pigeons' eggs, sharks' fin soup, various meats, preserved eggs 300 years old, which our consul said belonged to the Ming dynasty (let me say that they looked it), and other luxuries too numerous to mention. Claret, samshu (distilled spirits made from barley), and champagne were also served. The samshu was a very strong and potent article.

After a very pleasant entertainment, the Taotai appointed the hour of 9 o'clock in the morning of the next day as the time for making his return visit as the representative of the Viceroy. We then took our departure, the party returning to the ship with the exception of Ensign Logan and myself, who, accepting the hospitality of the mission, remained behind in order to visit the Chinese arsenal.

The arsenal occupied a space of some ten acres in extent. The buildings were of brick and in good repair. The estimated value of the plant is $200,000. This arsenal supplies three provinces. We saw them manufacturing Krupp six-pounder steel breech-loading howitzers, and Gatling and Nordenfeldt machine guns. The superintendent, foremen, and all employes were Chinese, and 10 hours constituted a day's work. From 700 to 1,000 men were employed, the price of labor ranging from $3.00 to $50.00 a month, the last rate being for skilled labor. The first and fifteenth days of the month are given as holidays. The iron and steel used was made from native ores at the arsenal, but the tools and machinery were of English manufacture.

The arsenal grounds include the site of the celebrated porcelain tower that was destroyed by the Taepings, no vestige of it now remaining. This pagoda was built in 1413–32 A. D., by the Emperor Yungkoh, in commemoration of his mother. It was 322 feet in height, slightly tapering, and consisted of nine stories, each provided with a gallery and a projecting roof, from the corners of which bells were suspended. In the interior, a spiral staircase led to the summit, which was surmounted by an elegant spire, on top of which rested a ball of brass plated with gold.

Returning to the mission, we remained there over night. The next morning, by invitation, Père Chevalier, Mr. Logan, and myself accompanied Taotai Lin on his visit to the ship, where he was entertained at breakfast by the captain and his officers. After breakfast he was shown over the ship, and, on leaving, a salute of twenty-one guns was fired in his honor.

The next morning we got under way, returning to Chinkiang, where we arrived at 11 o'clock that forenoon.

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THE HIGH BUILDING

Maurice M. Sloan

THE REASONS FOR THEIR EXISTENCE AND ADOPTION—THE EVOLUTION OF THEIR DESIGN AND CONSTRUCTION

LITTLE more than two decades ago a ten-story building was a curiosity and a wonder to all. It was the place from the top of which the stranger within the gates could gaze on the busy life spread out like a panorama at his feet. Today, on the roof of such a building situated in the center of an American metropolis, one would feel as though at the bottom of a chasm, for on every side nothing can be seen but the high and usually unbroken window-pierced walls of structures that can well be termed 19th-century giants. The large cities are not the only localities in which such masterpieces of architecture and construction can be seen, for no ambitious provincial town is complete without at least one such building. In size, these towering structures rival those wonders of the ages, the Egyptian temples and Gothic cathedrals, but they are of such unusual construction, compared with the ancient and medieval prototypes, that they have brought about new conditions, which have been met and successfully combated by an evolutionary process placed in operation some fifteen or twenty years ago, when what is known as *skeleton construction* was originated.

"THERE IS BUT ONE THING TO DO, AND THAT IS TO BUILD UPWARD, ADDING STORY UPON STORY"

Skeleton construction in its literal meaning can hardly be called a modern innovation, for the old-fashioned half-timbered structures in such evidence throughout Continental Europe and elsewhere across the sea are just as truly types of a structural framework filled in or covered with a screen, as is our most modern office building; hence, the architects and engineers who are so much exercised as to the first constructor of this type of building should not look toward Chicago or New York, but to the practice in the old world in the 16th and 17th centuries. To the American architect or engineer, however, is undoubtedly due the credit of introducing the extensive use of steel in skeleton construction, and consequently the opening up of possibilities in the way of gigantic structures that compare in size with ancient engineering and architectural work, and this, too, at a cost that admits of their being erected in this age of economy and utility.

From the very fact that these modern giants are built within a reasonable cost, they lack the solidity that was such an evident feature of medieval and ancient architecture. They are, to the classical student, works of architectural dishonesty. They are deceptions to his trained eye, which has been educated in the proportioning of masses of masonry relying on its own unyielding strength, without the reenforcement and support of a metal backbone. He feels that the first principle of art is honesty, and rebels against these products of the utilitarian and economist.

In the evolution of the world's progress, possibility has usually followed close in the footsteps of necessity. The concentration of business in one locality of the great cities increases the price of building sites to such extravagant figures that capitalists, in order to realize on their investments, must look

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around for a remedy. There is but one thing to do, and that is to build upward, adding story upon story, reaching heights limited only by the boldness of the designer. Such heights might have been reached by the old method of construction—that of supporting all the weight upon masonry walls and partitions—but, by the employment of this system, walls of such thickness and solidity would be demanded that the structures would have been hardly more than monumental obelisks, pierced at intervals with narrow and deeply recessed openings.

It was quite evident to the architects and engineers that solid masonry walls would not do; it was necessary to use some other material and to support the weights in another manner. Iron, or, better still, steel, which was becoming cheaper and cheaper each year, was looked to for the solution of the problem. The use of this material offered advantages that were of the greatest importance: Through its strength and reliability any height of building could be attained; on account of the thin walls made possible, a maximum economy in floor area is gained; and, since the weight of the building and the loads on the floors are supported by the columns, the space taken up by the masonry in the old method of construction could be utilized for the necessary number and size of window openings. Another advantage, and one that cannot be lightly regarded when the building is being erected in a crowded thoroughfare where the loss in rental for a month or two means thousands of dollars, is the rapidity and facility of erection.

The great principle of steel construction, as compared with the old system of building, is that all the loads on the floors—in fact, the entire weight of the building—are concentrated on the foundation through the columns. In the old type of construction, the problem was to distribute the weight of the building on footings extending throughout the length of the walls, both exterior and interior. Skeleton construction concentrates the loads on piers or isolated foundations, the foundations being proportioned accurately for the load on them. This renders the foundation problem more definite, and, to some extent, more simple; for the settlement is reduced to a uniformity, and enormous strains due to unequal settlement are unknown with carefully designed isolated foundations.

The walls in the new construction cease to be a structural feature, becoming a curtain or a screen for the purpose of providing shelter and an architectural surface. These walls, not more than 16 inches thick and frequently less, often built of light terra-cotta, are supported not directly from the foundation up, but on steel beams secured to the columns at each floor. Not having great weight to sustain, such walls can be pierced with wide window openings at short intervals, which, on account of the shallow recesses, admit a maximum amount of light to the interior, an important consideration in a building occupied by numerous professional men and clerks. Since these light walls are supported at each floor, it is not necessary in erection that the masonry should begin at the foundation, and it is not an unusual thing for the observer to see an office building with the upper ten stories apparently completed, walls, cornices, crestings, and all, propped up on the great steel frame, which looks as though it was ready to walk away. In concentrating the entire load of the building on the columns, heavy interior walls can be omitted and the floors of the building may be partitioned off in any desirable manner. It can thus be seen that the use of steel as a framework for high buildings gives greater economy of floor area, increased lighting facilities, and larger opportunity in the arrangement of rooms than the old-style construction could possibly have done.

It is not strange that the new system of construction should have its birth and rapid growth in the energetic West rather than in the conservative East, and nowhere can the evolutionary process that produced the high buildings be traced so clearly as in Chicago. This city, it would seem, contained the conditions that demand the boldest efforts of its architects and engineers, and they deserve the greatest amount of credit for the pioneer work that has been done to develop steel construction. While it is true that the West was bolder and more rapid in the conception and execution of these great structures, it can hardly be said that it produced the best examples; for the East, with its greater wealth and conservatism, supplied the fineness in details that makes the high office buildings in this section of the country the *summum perfectionis* of the new type of construction.

In the design of these great structures, three difficult problems, besides numerous minor ones, came up for solution almost simultaneously. The first was the question of foundations, which, on account of the great

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"Second Only to the Foundation Problem Was That of Wind Bracing"

weight concentrated on isolated piers, must necessarily offer great bearing surface. The second was that of wind bracing, for many of the structures rearing high in the air above the neighboring buildings were narrow and often offered large blank surfaces to the force of the wind. The third great problem, and one that, in the opinion of many engineers, is far from a satisfactory solution today, was that of fireproofing.

The careful consideration required in the construction of the foundations necessary to support the great loads of such tall buildings was due to the concentration of the weight from large floor areas on isolated piers, the only supports of the structure. Owing to the great loads, far more than were ever imposed in the old type of construction, very careful inspection of the soil was necessary in order that its bearing properties might be ascertained. The ideal bearing stratum from which to commence the foundations was hard pan or rock. Many localities were not fortunate, however, in having such strata near enough to the surface to make it practicable, and the ingenuity of the constructor was taxed to provide adequate support for the great superimposed structure. Chicago, the birthplace of the tall building, was particularly unfortunate in possessing an upper stratum of compact clay on a yielding stratum of loam and quicksand containing soft and spongy pockets.

The use of piling in order to transfer the weights to the substratum of rock was practically impossible in this locality, because of the great distance from the top soil to this secure foundation. To attempt to improve the bearing value of the soil by driving piles that did not reach the hard stratum was found to be useless, for the reason that when the comparatively shallow and compact upper clayey stratum was broken through by piling, its bearing value was diminished rather than increased. There seemed to be but one thing to do, and that was to float the buildings on rafts formed of cross-layers of steel rails or I beams, well surrounded and embedded in concrete, which provided not only a resisting medium through which the rails and beams transferred their load to the soil, but it insured the steelwork against the corrosion that was sure to take place if it were not protected in some way against the moisture that always exists in such soils. This style of foundation, which is known generally as *spread* and particularly as *grillage*, was the outcome of the demand for the adequate support of the enormous superimposed weight created the modern high building.

The grillage, or spread, foundation, while characteristic of the building erected along the lines of skeleton construction, was not by any means the only type used; for, on account of the premier importance of reliable foundation, the constructor devoted much thought to this part of the structure, and the result was the adaptation of several old ideas and the origination and execution of many new ones. Among these, probably the one most frequently used is that known as the *caisson*. These foundations consist usually of steel cylinders, or caissons, which are sunk by various methods through the soft upper strata until they come to a bearing on the solid rock or hard pan. The interior of the cylinder, which has been excavated in the process of sinking, is then filled with concrete, which, when set, forms a solid monolithic pier reenforced by the steel cylinder, and is capable of sustaining almost as much weight as can be brought to bear on it.

Second only to the foundation problem was that of wind bracing; for, though the solution could readily have been arrived at in some fashion, the question was how to do so economically and in such a manner as not to interfere with the planning or the arrangement of the interior of the building. The wind, as we all know, blows with considerable force—a force that at times is irresistible—and it is generally conceded that the velocity of the wind is greater some distance from the ground, though such is not by any means always the case. It is, however, an accepted fact among engineers that a wind pressure of 30 pounds to the square foot occurs in most localities at frequent intervals, and that it often reaches 40 pounds

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per square foot. Buildings constructed in the old way resisted these pressures by the inert weight of their walls and because of their moderate height, and also on account of the exposed surfaces being small compared with the area of their bases.

It is quite reasonable to suppose that no modern building of great height is rigid enough to topple over, for the light walls will crush or collapse before sufficient force can be exerted to lift the great weight of the structure from its base. All the accidents that have occurred to high buildings from wind pressure go to substantiate this reasoning, and it has been demonstrated that the inertia of the exterior walls of a building erected on the principle of skeleton construction cannot be depended on to resist the great force created by the wind when blowing at a high velocity. This latter fact was definitely proved by an accident that happened to a building of moderate height in New York. At the time of the accident, the ironwork had been practically completed, and the brick walls were finished to the top of the eighth story, leaving only the bare ironwork of two stories exposed to the wind. The building, though of the skeleton-construction type, had cast-iron columns and bolted connections. The bolts did not fit the holes accurately, and every connection resembled a hinge joint with considerable play. When the building had reached this stage of construction, an unusually heavy wind storm occurred, and on the morning after the storm, to the surprise of those engaged on the work, it was found that the whole structure from the top of the fifth story upward had swung over to the west, so that the top was 11 inches out of plumb. It was further discovered that the ironwork had swayed over until the slack bolts and other loose parts had come to a bearing and then stopped. The building to which this accident occurred was of very nearly the same proportions as the one shown in the illustration, and was similarly situated with reference to the adjacent buildings.

In such a building, while a system of wind bracing is hardly required, some attention should be paid to the securing of rigid connections in the beam and column attachments. Since bolted connections are not rigid, and can never be made so, only well-riveted joints should be relied on in such a building. Where structures of less than ten or twelve stories are provided with well-constructed transverse partitions and rigid floor systems, they are undoubtedly sufficiently stiff to resist any wind pressure that may come upon them; but with buildings of greater height, there is a liability of lateral motion, not only from the wind but from vibrations and oscillations from other causes, and the proper bracing of such buildings is a problem that requires the greatest care in order to arrive anywhere near the correct solution.

Three methods of wind bracing that seemed feasible and practical presented themselves to the designer of the modern office building. The first system that was adopted, and one that answered well enough in some cases, was known as *knee bracing*. This consisted in placing steel struts from a system of floorbeams to the adjacent columns in the same manner that the corner posts of a framed house are constructed. This system, however, has the serious objection of creating bending moments in both the columns and the beams, which must be overcome by proportioning these members to sustain the increased transverse stress. These knee braces, instead of being diagonal

"THE BUILDING TO WHICH THIS ACCIDENT OCCURRED WAS OF VERY NEARLY THE SAME PROPORTIONS"

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"Where Massive Steel Trusses Support the Roof They Must Likewise Be Protected by Porous Tile"

members, were often constructed by placing a triangular gusset plate in the corner formed by the floorbeam and the column, the hypotenuse of the triangular piece being reenforced and stiffened by angles back to back.

The diagonal sway-rod system, which is one much used where it can conveniently be adopted, offers probably the simplest solution to the problem of obtaining reliable wind bracing. This system consists of running a tension rod diagonally between the foot of the column on one side of the tier to the cap of the column opposite. This, of course, only takes care of the stresses created when the wind blows from one side; consequently, it is necessary to cross this diagonal with another in the opposite direction. The objection to these sway rods is that they interfere with the arrangement of the partitions and with door openings and, in some cases, window openings, so that it is sometimes impossible to adopt this method of bracing.

The portal bracing is similar to the knee bracing, and is simply a steel arch with its accompanying abutments placed between the columns and floorbeams, as shown in the illustration. This system of bracing has many advocates among the architectural engineers, the claim being that, while they are hardly as cheap as sway rods, they lend themselves to the architectural treatment of the interior, and, when decoratively plastered, they have the appearance of a symmetrical and well-proportioned arched opening. The difficulty of proportioning the members in any of these systems lies in the fact that, in considering the rigidity of the steel frames, the resistance of the floors and partitions to lateral movement is an unknown and indeterminate factor. The safest and most reasonable method of figuring would therefore seem to be to disregard such factors as these and to proportion the bracing to carry the entire load created by horizontal wind bracing. This latter method, while not the more economical, is at least the surer and safer, and should be adopted wherever the cost will allow.

It became imperative with the advance in steel construction that adequate means of fireproofing should be provided. It was very evident to the architects and engineers that, where the building depended for strength and support on steel, the steel must be protected in case of fire. The structural members of the building were of steel, a non-combustible but not refractory material, The sections composing these members were not of great thickness, and a moderate degree of heat would quickly cause them to become red-hot, destroying their strength, and, at the same time, the expansion caused by the overheating would twist and wreck the structure. It was necessary, therefore, to protect the steelwork with the most refractory materials that could be conveniently used. This problem of fireproofing therefore brought forward the many systems of floor and partition construction now in vogue.

The subject of fireproofing was one that required much thought and careful consideration, and reliable results could only be arrived at by experiments, or, better still, by close inspection and investigation of all fires that occurred in buildings of the so-called fireproof class. Much has been said to show that fireproof buildings are so in name only, and that no construction can possibly be fireproof. It has been pretty clearly demonstrated by several large fires that have occurred in business sections that the fireproof building stands while its neighbor of different construction goes down. It is impossible, of course, to prevent the occurrence of fire in any building, for there is within every building and every room in the building sufficient combustible material to create considerable heat. The furniture,

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usually of wood, is covered with combustible varnish over which the fire, once started, will pass with great rapidity and generate considerable heat. As long as fireproofing material clings to the columns or beams, the steelwork is comparatively safe, and even where the steelwork has become greatly heated, it has not been found to be materially damaged. In fact, the quality of the material is sometimes better than it was before, since it has gone through an annealing process.

Any fireproofing material must, of course, be a non-conductor and must have considerable strength in order to resist the force of the water from the fire hose, and also excessive contraction due to rapid cooling. It should likewise be somewhat elastic, that it may go and come with the expansion and contraction of the steelwork which occurs at all times with the changes of temperature. However, this expansion and contraction is not as great as it might at first appear, on account of the uniform temperature that is usually maintained in such buildings throughout the year. Not only must the walls, floors, and partitions be fireproof, but where massive steel trusses support the roof, they must likewise be protected by porous tile, wired on or otherwise secured to the steelwork, the joints being thoroughly filled with fireclay or fire-resisting cement.

While the modern high building is most eminently adapted, with its isolated rooms and fireproof partitions, to resist fire, any such construction is greatly aided by an efficient and at all times thoroughly workable system of fire protection. It is the skilled designer and the far-sighted owner of such buildings who take great care in providing fire protection to place roof hydrants on the top of the building, in addition to the usual hydrants and hose on each floor. The roof hydrants furnish excellent means of protection from adjacent fires. Not only will they oftentimes save the building on which they are located, but they are invaluable in protecting adjacent property.

The important feature of all such individual fire protection is that the apparatus shall be in good condition in the time of necessity. Often the hose is rotten, the pumps are stopped, broken down or uncoupled, and, at the critical moment, the failure of one part of the system is the failure of the whole.

The many other problems that the constructors of these modern edifices have had to solve would fill several volumes. These problems have confronted not only the architect and engineer, but also the sanitary engineer, the plumber, the machinist, and, in fact, almost all those engaged in the industrial sciences.

These buildings, containing as many as 5,000 occupants and sending out as much mail matter as a city of 20,000 inhabitants, are veritable towns, throbbing with life and energy. Their basements are filled with boilers, engines, and electric-lighting apparatus, refrigerating plants, and elevator machinery. Many of them have reserve coal bunkers that carry enough fuel for an ocean liner, and this is held in reserve in case of strikes or other delays in obtaining fuel.

So it is that the visitor unused to the busy life of a great city is inspired with awe on entering one of these modern towns under a single roof. From the basement, with its quick-moving machinery, to the roof garden and restaurant, twenty-five stories above the pavement, all is strange and wonderful. More wonderful still is the man with the phenomenal memory who stands at the door with the name and room number of each of the 5,000 occupants at his tongue's end. Not so strange, perhaps, as the volume of business that is carried on in one of these great buildings, an adequate conception of which can be gained nowhere so readily as when one stands in front of the mail chute and sees a constant stream of letters coming down, sometimes in flurries and sometimes so continuous as to lap one another.

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MODERN ELECTRIC-LIGHT WIRING

Thomas H. Cooper

THE IMPORTANT POINTS TO BE CONSIDERED—WIRING BRANCH CIRCUITS—PANEL BOARDS—IRON CONDUITS AND PORCELAIN WORK

THERE have been a great many changes in recent years in electric-light wiring, and the standard at present is so much higher than it was a few years ago that to do the work properly requires some ingenuity as well as mechanical and electrical knowledge. While the electrical work in private houses and buildings in general is as necessary and fully as complicated as in any of the other branches, and, if improperly executed, as much of an annoyance and an ever-existing source of danger, yet very little thought is given to it by the average architect, who allows the wireman to exercise his own judgment to a great extent.

The important points that demand attention are: the number of lights to be used; the location of panel boards or cut-outs and switches, the laying out of wires to the best advantage in order to do as little cutting as possible, save material, and keep the circuits balanced, and the style of work best adapted to each particular case.

If the current is to be taken from the street conduits, the starting point is at the service block. Here on a solid wall, a loop should be left in the mains for the meter; on the feeding side of the meter set a two- or three-wire cut-out, as the service may demand, of sufficient size to carry the full load. Run the main wires from the cut-out to a point as near the center of distribution as the circumstances will permit. Choose a partition that runs from the first floor to the top of the building and marks the hall line. Run the mains in this partition to the bottom of the bus-bars of a panel board set in the wall of the first floor, and from the top of the bus-bars of this panel board to the bottom of the one on the second floor, and so on to the other floors, ending in the last panel board.

The accompanying illustration shows an up-to-date panel board mounted in its casing. This particular board is arranged for three-wire mains. These come up through the partition and are attached to the bus-bars *b*, *b*, *b* by means of the lower lugs. The mains leading to the upper floor are attached to the upper lugs. The various branch circuits pass out at the side, and each is provided with a small double-pole switch *s* and enclosed fuse *f*.

Now that the mains are in, and supposing the panel boards to have been properly designed, we have on every floor a fuse and double-pole switch conveniently located for each circuit, and the lines are properly balanced as to load. The next thing to look after is the wiring of the branch circuits. These start from their respective panel boards and should run as straight as possible to the outlet. Judgment must be exercised in each case as to the number of lights each switch should control, but no more than ten 16-candlepower lights should depend on one pair of fuses. By this method, if the circuits are numbered in the panel board and a card or key fastened on the inside of the door, each circuit can be controlled without confusion, and, in case of trouble, the defective circuit can be located at once.

To find the size of wires required for mains, divide the number of 16-candlepower lamps to be used by 2; this will give the ampere load near enough for practical purposes. The following table shows the amount of current allowed by The National Board of Underwriters for each size of wire:

CARRYING CAPACITY OF WIRES

B. & S. No.	Rubber-Covered Wires. Amperes.	Weatherproof Wires. Amperes.
18	3	5
16	6	8
14	12	16
12	17	23
10	24	32
8	33	46
6	46	65
5	54	77
4	65	92
3	76	110
2	90	131
1	107	156
0	127	185
00	150	220
000	177	262
0000	210	312

This table is perfectly safe to follow unless the total length of wire is very long, in which case the number of volts lost must be taken into consideration and the size of conductors

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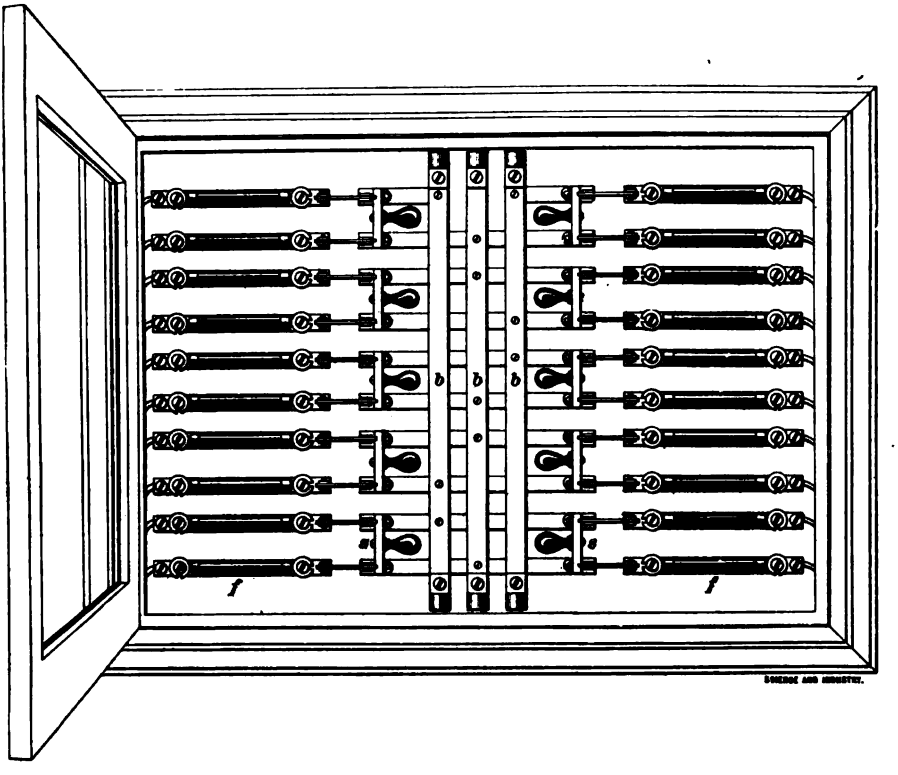
increased in proportion. A loss of 2 or 3 per cent. is usually figured on. It is not allowable to use a conductor of smaller size than No. 14, B. & S. gauge; this has sufficient cross-section to carry the full permissible load for each branch circuit of 10 lamps.

For concealed work, we can choose between iron conduits and porcelain work. Conduits are the best, because they provide runways that allow conductors to be removed at any time and others drawn in. Porcelain work has the advantage of cheapness, and, if properly installed, it makes a very good and safe job.



There are two systems of conduits, one employing a separate pipe for each conductor, and the other a single pipe for both conductors. These conduits are lined and unlined. With those lined with insulating material, the ordinary rubber and single-braid wire can be used. With the unlined, it is necessary to use a wire with a second braid, cover equal in thickness to the lining of the insulated conduit. It is advisable to use the unlined single-pipe system, because of its cheapness, the ease with which conductors may be inserted and removed, and also because if it is desired to change from direct to alternating current, no inductive disturbance will take place.

In all conduit installations, the straighter the wires are run the better will be the job; but since long spans of floorbeams cannot be cut, it will be found necessary to use bends and elbows. A good rule to follow is not to have more than four bends from outlet to outlet, not counting elbows at the outlets. At every outlet, use outlet boxes set flush with the plaster and fastened securely to a floorbeam or board nailed between two beams. The whole conduit system is installed without the conductors, which are drawn in when all the mechanical work on the building is completed. The pipe must be securely strapped to the beams, all ends reamed, and the joints made tight with white lead. The pipe must enter all outlet boxes and be fastened so that it cannot slip back.

In porcelain work, these hints as to runs hold good also. Splicing of conductors should be avoided, and can be in a great many cases; but when splices are made, the copper should be thoroughly cleaned, the joint tightly made up and soldered, all acid wiped

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off, and the joint taped until an insulation equal to that of the wire is secured. Where lugs are used, the wires must be soldered into them. It will be found to be much better to use stranded wires instead of solid ones in the larger sizes, say from No. 6 up. A hardwood box lined with asbestos, and with a door closing on a rabbet, may be used instead of the panel board. The required number of cut-outs and switches placed in such a box give the same effect at less cost than a regular panel board. The conductors enter the box through porcelain tubes when porcelain work is employed, and the conduit enters the box in the other system.

In damp places, such as cellars, breweries, etc., porcelain work is the best. If the ceiling is plastered, painted boards carrying porcelain knobs or cleats are fastened to the ceiling about 4 feet apart, and these support the conductors and allow a free circulation of air. If cut-outs are installed in these places, they should be in tight fireproof boxes. The drops should be fitted with porcelain or mica sockets and soldered direct to the branch wires.

In factories, mills, etc., the wiring is run open, with porcelain cleats placed not more than 4 feet apart, the wire passing through partitions and floors in porcelain tubes and the risers being run in molding; the cut-outs and switches are grouped in asbestos-lined boxes on the side walls. The drops consist of cleat rosettes fused and backed with asbestos, lined key sockets, and cotton-covered flexible cord. This installation is neat, cheap, satisfactory, and is easily accessible.

In this work, cut-outs must be set wherever a smaller wire leaves a larger one, and the cut-outs fused to protect the smaller wires. Solid taps may be made on the same size of wires. Where wires cross each other or are liable to be disturbed American circular-loom conduit or porcelain tubes can be used. The wires should be run straight and pulled tight, and cleats, rosettes, and cut-outs securely fastened with screws. Where loom or tubes are used, they should be taped to the wires so that the jar on the building will not shift them.

If it is desired to partially conceal the wires and produce a still neater job, molding made of two pieces—a backing and a capping piece—with a center tongue to keep the conductors ½ inch apart, may be used. Such molding must be thoroughly painted and all joints neatly mitered. The result is electrically first-class, and not at all unpleasing to the eye. These moldings, made of hardwood in fancy designs, can be obtained, and are often employed to great advantage in really well-finished rooms.

In all cases, neat and careful work and attention to details will make the inspector's visit a pleasure to look forward to rather than an event to be dreaded.

This article, it is hoped, will, in a general way, give some useful hints on wiring as it is practiced in large cities at present. We will take up the different methods in a separate article on each, and explain in detail how the work is done, what tools are required, etc., and give a description of an installation under each method.

CARE OF PLUMBING IN VACANT HOUSES

Thos. N. Thomson

ARRANGEMENT AND CARE OF PLUMBING AND WATER FIXTURES IN A COUNTRY PLACE THAT IS TO BE UNOCCUPIED DURING THE WINTER

SUMMER homes should be provided with plumbing that can easily be prepared to withstand the action of severe winter weather. It is therefore customary in cold climates to grade all water pipes down toward points where the water can easily be drawn off. All pockets that cannot be avoided should be provided with drip cocks so located that the inmates of the building can operate them. The traps of all fixtures should be accessible so that they may easily be emptied when desired. Pumps, hydraulic rams, hot-air engines, and all other machinery should also be provided with drip cocks. A card of instructions telling where and how to shut off the water and drain the pipes, etc. should be hung in the kitchen, particularly when the building is far away from a plumber's shop. A drawing showing all the pipes on the premises should, if possible, be pasted on the board. This will enable any intelligent man to avoid

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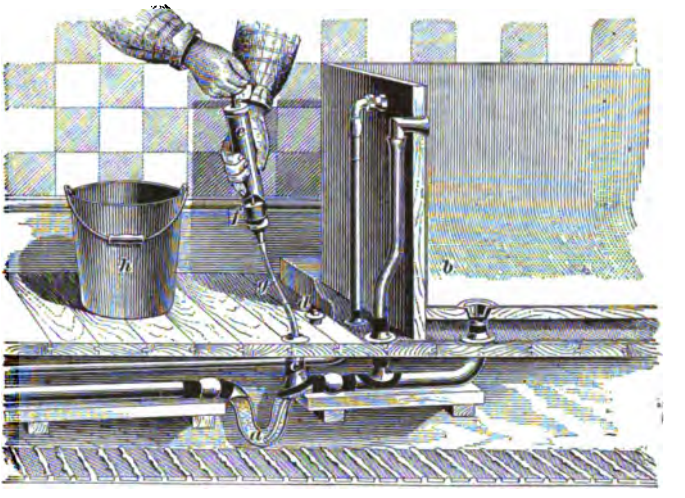
unnecessary damage to the building by leaks or from frost. It is advisable, however, for plumbers to prepare the plumbing for winter.

The preparation of an ordinary country estate for winter, assuming that the place will be vacant until spring, is about as follows:

1. Shut down the pumping engines.

2. Drain all tanks completely, and clean them out as they empty.

3. Disconnect all roof leaders that may flow into them, allowing the water to flow to underground cisterns (if any) provided for winter water storage.



4. Drain all pipe lines by opening all fixture cocks and all drip cocks. Blow through the several lines of pipe, to be sure that they are empty.

5. Drain the kitchen boiler by opening the sediment cock, and be sure that the water back in the range is so constructed that it will be emptied at the same time.

6. Drain all pump cylinders, water-jackets, and other receptacles about the pumping machinery that may retain water, and do not forget to lift the pump valves so that the suction pipes may empty back into the wells. If the pump valves are down the well, or if there is a foot-valve on the suction pipe, do not forget to open the drip cock attached to the side of the pipe in the well below the frost line.

7. Unscrew all trap screws, to drain the traps that are accessible. Use a common suction pump to drain traps under the floors, as shown in the accompanying illustration. Fill all fixture traps with crude glycerine, which is a liquid that will not freeze nor evaporate.

8. Take the vanes off the windmill to prevent it being wrecked by winter storms while it is "off gear," that is, when it is not pumping water.

9. Dry all the working parts of the machinery, and oil or grease them to prevent them from injury by rust during winter.

10. Drain the water from all gas-making machines, etc. that will be subject to injury by frost.

Winter homes should be provided with plumbing that can easily be prepared to withstand the action of summer weather when the building is vacant. Owing to the fact that traps lose their water seal by evaporation when fixtures are not in use, it is necessary, as soon as the house is vacant, to drain the water from all fixture traps and fill them with crude glycerine. If this is not done, the traps may be completely unsealed within a month, and sewer gas will blow into the building as freely as if there were no traps.

It is also advisable to empty the water tanks, if any, and shut off the water where the main service pipe enters the cellar. This will prevent meddlers from washing the glycerine out of the traps, and at the same time prevent leakage in the vacant building. All pumps, machines, and other apparatus containing water should remain charged to prevent the leathers and valves from becoming dry. Water pressure should be allowed only on the garden or lawn hydrants while the building is vacant. This will allow the attendant, if any, to water the garden or grounds, if desired.

A placard should always be attached to a range having an empty water back, to prevent people from starting a fire before the water is turned on.

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THE ANALYSIS OF COAL

Charles P. Turner

THE VALUE OF AN ANALYSIS—THE ULTIMATE AND PROXIMATE ANALYSIS—THE LABORATORY—SELECTING THE SAMPLE—STANDARD LABORATORY METHOD

THERE are many cases in which it is desirable to make various tests of the fuels used in steam making. In buying coal it is very useful to be able to make such tests as will reveal its approximate theoretical heating value and its probable capacity as a steam maker. Such tests will greatly assist the buyer in selecting the particular grade of coal that will produce the greatest number of heat units and evaporate the maximum weight of water for the money expended. Of course, the most reliable method of testing the evaporative capacity of a fuel is by burning it in the boiler furnace under regular running conditions, and carefully weighing the water evaporated. Such a test, however, is cumbersome and expensive, and is not available as a ready method of testing small quantities of fuels whose use is under consideration.

In order that a boiler trial which is intended to show the efficiency of a boiler as a steam generator, or of a furnace as a coal burner, may have any real value, it is especially important that the theoretical heating value of the fuel be accurately known; without this knowledge, the trial will have but little value for the purposes of comparison. Unfortunately, there are many difficulties to be overcome in so conducting tests and analyses of fuels that the results obtained will be reasonably accurate and reliable. The quantity of fuel used in making the test is very small, seldom more than a small fraction of an ounce, and great care is required to so select and prepare a sample that it will be a fair average of the coal to be tested. The small quantities handled and the accurate measurements demanded, in order to furnish reliable results, involve the use of the best of scales, thermometers, and other measuring instruments. These instruments are delicate and expensive, and much skill, which can only be acquired by practice, is essential if reliable results are to be obtained by their use.

There are two classes of tests by means of which the theoretical heating value of a fuel may be estimated: *First*, chemical analysis may be made that will show the percentages of the various elements, and, from this analysis, the theoretical heat of combustion may be calculated; *second*, the heat developed when a sample of the coal is burned may be measured by an instrument called a *calorimeter*.

There are two analyses of coal that may be made, each of which furnishes information of considerable interest and value to the engineer. Of these analyses, one, called an *ultimate analysis*, determines the percentages of the various chemical elements of which the coal is composed, but does not necessarily show in what manner these elements are combined. It shows that, if a sample of the coal is separated into its elements, there will be certain proportions of oxygen, hydrogen, carbon, etc. These proportions are generally expressed as percentages of the weight of the original sample, the weight of which is considered as a unit, or 100 per cent. From the ultimate analysis, the heating value of the coal may easily be estimated by the following rule:

To find the approximate heat of combustion of a pound of coal, multiply the weight of the carbon in hundredths of a pound by 14,500. Divide the weight of oxygen in hundredths of a pound by 8, and subtract the quotient from the weight of the hydrogen, also expressed in hundredths of a pound. Multiply the remainder by 62,000, and add the product to the first product.

The heating value of coal depends only on the percentages of carbon and hydrogen; an analysis that shows the percentages of these two elements would, therefore, be sufficient to enable an estimate of the heating value to be made. It is customary, however, to determine the percentages of all the elements in the volatile and combustible matter. The ash, which consists of various minerals that are not readily broken up into their elements by the action of heat, is seldom analyzed in tests of fuels that are to be used for making steam. The ultimate analysis of a fuel is a difficult and expensive operation that can be successfully performed only by a skilled chemist, with the facilities of a well-appointed laboratory. Owing to its expense, it is seldom made except in such cases as important boiler trials, where it is desired to obtain the most accurate information

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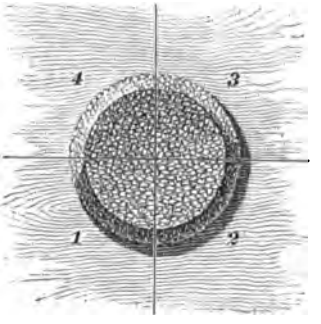
possible regarding the properties of the fuel used.

Although the ultimate analysis of a fuel presents difficulties that render it impracticable for any but a skilled chemist, there are methods by means of which a careful engineer can acquire an amount of skill that will enable him to determine the percentages of water, volatile matter, fixed carbon, and ash with a fair degree of accuracy. For successful work, a laboratory should be fitted up in which all the instruments required may be kept in a convenient position for use. This laboratory should be well lighted, heated, and ventilated, and located where it will be as free as possible from dust, jars, and sudden changes of temperature. It should be provided with a supply of illuminating gas; a sink with running water is also a very desirable, if not a wholly essential, feature. A substantial work table and convenient shelves and drawers, where all samples and supplies may be kept, are the most essential articles of furniture; a writing desk with pigeonholes and drawers for books, papers, and records will be a valuable addition. The top of the work table should be at such a height above the floor that the operator can stand at his work without bending; about 36 inches will be a convenient height for most men.



If the laboratory is located in a building whose walls are subject to vibrations from running machinery, or in a room without a substantial floor, special foundations for supporting a table for the balance should be built. These foundations should be carried down to rock, gravel, or hard pan, and should have no connection with the foundations of the building or machinery.

The instruments and devices necessarily required are a sensitive balance with a box of weights, a platinum or porcelain crucible and stand for it, a Bunsen burner, and a blast burner.

The first operation in making a fuel analysis consists in the selection of a sample that will fairly represent an average value of the fuel. Pieces of coal are selected at random here and there, until about 100 pounds have been collected. These should be broken up into pieces approximately equal in size, and the pieces then thoroughly mixed. A conical pile is now heaped up, and by continually raking down a little coal from the pile, a flat circular pile about 4 inches thick is formed, as shown in the figure. Next, mark the pile off into quadrants and remove two of the sectors diagonally opposite each other, as *1* and *3*, or *4* and *2*. The remaining coal should now be broken up into a smaller size, and the whole operation gone through again. This should be repeated until the coal has been pulverized, and only about a pint measure full is left. This amount is then finely pulverized, and spread out on a piece of glazed paper, in a circular form. It is now divided into, say, 8 equal sectors, and the amount to be subjected to analysis is then made up by taking equal parts from each sector in succession. Owing to the fact that the composition of the coal is to be expressed in per cent. of the weight of the sample, it is customary to use the metric system of weights, which is, in fact, the system universally used by chemists.

Since this system is comparatively unknown, a short explanation of it is here given. The unit of weight is the kilogram, which is divided into 1,000 grams. The gram is subdivided again into 1,000 milligrams. Then, the milligram is the one-millionth part of a kilogram. Expressed in grains, 1 kilogram weighs 15,432.35639 grains; 1 gram weighs 15.43235 grains; and 1 milligram weighs .01543 grain.

The analysis of coal is performed in the following order: determination of moisture, determination of volatile matter, determination of carbon, and, finally, determination of the ash. It is based on the fact that the moisture and volatile matter can be driven off by heat, and that by increasing the heat to the igniting temperature of carbon, the latter can be burned, leaving behind the incombustible substances known as *ash*.

In order that the results obtained may be compared with those obtained by others, it is essential that a uniform method be employed by all; that is, all chemists should use the same weight of coal to be analyzed, and should heat it for the same length of time, as given in the directions for the standard laboratory method explained below.

To determine the moisture, weigh out exactly 1 gram of the sample into a porcelain or platinum crucible and put in a drying

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oven in which a temperature of 225° F. is maintained. Keep it there for exactly 1 hour; allow it to cool, and then weigh the sample. The loss in weight represents the moisture. Thus, if the sample weighed 1 gram (1,000 milligrams) before heating and 912 milligrams after heating, the moisture weighed $1,000 - 912 = 88$ milligrams. Reducing it to per cent., we have moisture $= \frac{88 \times 100}{1,000} = 8.8$ per cent.

The volatile matter is determined by weighing out 1.5 grams (1,500 milligrams) of the undried pulverized sample into a platinum crucible and covering tightly. Heat it for 3½ minutes over a Bunsen burner, keeping up a bright red heat, and then heat it immediately, without cooling, over a blast burner for 3½ minutes at a white heat. Allow the sample to cool and then weigh it. The loss in weight represents the volatile matter, i. e., the hydrocarbons and the moisture. Thus, if the sample weighed 1,500 milligrams before heating and 1,149 milligrams after heating, the volatile matter weighs $1,500 - 1,149 = 351$ milligrams, and constitutes $\frac{351 \times 100}{1,500} = 23.4$ per cent. of the coal. Then, since the moisture is 8.8 per cent., the volatile combustible is $23.4 - 8.8 = 14.6$ per cent.

If a coke is formed in the preceding operation, make a note of its properties, color, firmness, etc. To determine the fixed carbon, place what is left of the sample after determining the volatile matter (1,149 milligrams in this case) into a crucible, and weigh it. Place this in an inclined position, with cover removed, over a Bunsen burner, and heat it until the carbon is all burned. By inclining the crucible and having it uncovered, the air can circulate freely in the crucible; this is essential, since the carbon cannot burn without the oxygen supplied by the air.

To determine positively when the carbon is all burned, heat until the ash appears to be free from carbon; then cool the crucible and weigh. Place it over the lamp again and burn for a few minutes longer; then cool and weigh. If the second weight is the same as the first, the carbon is all burned out and the crucible contains nothing but ash. If, however, the second weight is less than the first, more carbon has been burned out, and the process should be repeated until two successive weighings give the same result. The combustion of the carbon may be hastened by stirring the charge occasionally with a platinum wire. The difference between the weight of the crucible with coke and its weight with the ash remaining after the carbon has been burned out, is the fixed carbon.

Assume that the crucible and coke weighed 21,500 milligrams, and, after burning out the carbon, it weighs 20,650 milligrams. Then the carbon weighs $21,500 - 20,650 = 850$ milligrams. Remembering that the original weight of the sample was 1,500 milligrams, the percentage of carbon is $\frac{850 \times 100}{1,500} = 56.67$ per cent.

The ash can either be weighed directly or its weight can be obtained by subtracting the weight of the crucible from the weight of the crucible and ash, i. e., 20,650 milligrams. Let the crucible weigh 20,351 milligrams. The ash then weighs $20,650 - 20,351 = 299$ milligrams. Remembering that the sample weighed 1,500 milligrams originally, the percentage of ash is $\frac{299 \times 100}{1,500} = 19.93$ per cent.

Summing up, the sample shows the coal to have the following composition:

Moisture	8.8 per cent.
Hydrocarbons	14.6 per cent.
Fixed carbon	56.67 per cent.
Ash	19.93 per cent.
	100.00 per cent.

In making the proximate analysis, great care must be taken to weigh as exact as possible, and, also, any spilling of part of the sample must be avoided. The composition of the hydrocarbons not being given by the proximate analysis, the heating value of the coal cannot be accurately computed from the results obtained by it; the average composition of the volatile combustibles, however, varies in most coals but little from the composition of marsh gas CH_4; it will therefore be found that a very good approximate estimate of the heating value can be made by calculating from the percentages of fixed carbon and volatile hydrocarbons determined by the proximate analysis, under the assumption that all the volatile matter is composed of CH_4.

Under this assumption, the rule for calculating the approximate heating value from the percentages given by the proximate analysis is:

Multiply the percentage of hydrocarbons, expressed as a decimal, by 23,600, and the percentage of fixed carbon, expressed in the same way, by 14,500; the sum of these two products will be the approximate heating value of 1 pound of the undried coal.

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SEEDS THAT LIVE FOR YEARS

Geo. E. Walsh

PRESERVATION OF PLANTS BY SUCKERS—MORTALITY OF SEEDS—DISTRIBUTION—LONGEVITY. PERPETUATION—REAPPEARANCE OF PLANTS AFTER AGES

CARELESS of the individual, Nature is ever careful of the type, and to preserve the latter she will resort to means and methods of an extraordinary character. Most of her plants are propagated by their seeds, but if for any reason these organs gradually cease to perform their work, suckers are sent up at the base of the main stalk, to preserve the type. A large number of plants and trees that at one time depended largely, if not entirely, on seeds for their perpetuation, are now propagated by suckers, and we have reason to suppose that this change was effected because, for one reason or another, the seeds were threatened with extermination. The pineapple, the banana, and the eggplant are illustrations of this process of transformation from seeds to suckers. Rudimentary seeds are found in the fruit of all three, but propagation is almost entirely by suckers.

Preservation of plants by their seeds is sometimes quite uncertain. On the average, not more than 50 to 60 per cent. of the seeds of wild plants are fertile. Of those that reach maturity in a fertile condition, many are destroyed by birds or animals, others fall upon rocks or barren ground and fail to germinate, and a few produce young plants that wither in the hot sun or die in the struggle with other plants for a place in the crowded fields or woods. The mortality among the seeds and plants is thus immeasurably greater than among human beings. In the crowded fields, woods, and swamps, probably not more than 50 per cent. of the hardy seeds that fall to the ground produce mature plants, and among the tender varieties a survival of 5 or 10 per cent. would be considered large.

Nature, however, is a crafty sower, and she has protected some of her tender perennials and annuals in ways that excite our admiration. She uses various agencies for sowing her seeds. The wind and water are among the most important, and she provides the seeds of some plants threatened with extinction with wings to fly on the wind and sails to float on the water. The birds of the air and wandering beasts of the field and jungle are employed in scattering other seeds. The burrs in which some seeds are enclosed cling to the fuzzy tail and hair of animals, to be carried away to some distant location, where a more congenial growing place may be found. Local force is applied to the seed pods of other plants to make their propagation more certain. At the appointed time, when the seeds have reached full maturity, the pods burst with considerable force and explosion, expelling the seeds so that they fall in showers at a considerable distance from the parent plant.

These unique agencies of Nature to insure the perpetuation of her plants, furnish us with many curious and interesting studies, and demonstrate how determined she is to preserve the type. If all the agencies fail, she may on occasion resort to root and sucker propagation. It may happen in the course of time that a breed of birds or animals may be raised up that will devour the seeds of certain plants, and complete extermination would in time be effected if extraordinary methods were not adopted. Thus the pineapples and bananas, and the fruits of many other plants, could be destroyed every season and the perpetuation of the plants be in nowise endangered.

In the struggle for existence, however, the seeds play the most important part in the vast majority of plants, and it is only with a comparatively few growths that Nature has substituted the suckers for the seeds. We have plants in existence whose type and chief characteristics date back to the dawn of human history. They have fought the good fight in all kinds of soil and under favorable and unfavorable conditions. In spite of all the destructive agencies that Nature invents to destroy the individual, the chief characteristics of the type have been preserved. Some of these plants may no longer exist in the wild state, but that is due to the intervention of man. They have been transferred to the gardens and improved by selection and cultivation, until their relationship to their wild progenitors is almost lost. Nevertheless, the essential structures and characteristics are the same, and, under neglect, they would undoubtedly revert back to the original type. Man only seems to possess the power to thwart Nature in her work. It is possible for him to check

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and actually exterminate certain plants, and raise up others to take their place. He may sometimes find formidable enemies that will make his work a long and precarious one, but perseverance will ultimately reward his efforts.

In recent years, the study of plant seeds by the Department of Agriculture, state experiment professors, and private individuals has been of the utmost importance to science. The money spent in testing the seeds has been of great service to the farmers and horticulturists of the land. In all seeds offered to the department, 85 per cent. must germinate or the seeds are rejected. It is remarkable how large a percentage of apparently good seeds fail to germinate or show proper fertility to produce strong, healthy plants. In this connection, the relative vitality and longevity have been incidentally considered. That the longevity of seeds varies greatly is apparent to any horticulturist who has had any experience with plants. But it is a debatable question whether there is such a wide range of difference in the longevity of seeds as there is in animals and birds—a difference of centuries and even of a thousand years, as generally supposed to exist between certain species of whale and the small insects that live and concentrate in 24 hours a full, well-rounded life. We have no seeds that are born, live, and die in a day. A season is the shortest time of existence of any; but, in order to obtain the best results from them, they must be planted within a few months of their full maturity.

Another class of seeds will retain their vitality a full year. Gathered one season, they must be planted the next or they will fail to germinate. Thus, most of our annual garden plants produce seeds that have their vitality limited to twelve months. After that period they degenerate rapidly, and while a few might retain their power to germinate another season, the majority would be valueless. So general is this rule, that seedsmen make it a point to sell only fresh seeds every year, in order to maintain their reputation for dealing in good fertile seeds. The Department of Agriculture demands fresh seeds always, and those carried over a year would be rejected, even if they should happen to pass the test of fertility and germination.

However, there are seeds that can retain their life for wonderful periods, and in these we must recognize another one of Nature's peculiar methods to perpetuate indefinitely some favorite class of plants that may have been threatened with extinction. It would be difficult to ascribe all the reasons for creating such a wide difference in the longevity of seeds, just the same as it is impossible to explain why certain animals are doomed to a short existence and others to a long one. In this foreordination, there is some inscrutable law that we fail to grasp.

There are undoubtedly many wild stories current about the wonderful vitality and longevity of certain seeds. It is difficult to believe that the seeds of wheat found in the sarcophagi of Egyptian mummies retain their power to germinate after the lapse of so many centuries, and horticulturists scout the idea as one lacking in proof or demonstration. Seed corn from the ruins of Thebes has likewise been said to germinate after an existence of no telling how many centuries, and some have even gone so far as to assert that seeds from the Nile mud-and-straw bricks of the temples have retained sufficient fertility to germinate. But all official tests with these ancient corn and wheat seeds that have an undoubted antiquity have failed to make a single one germinate. It is more than probable that we must accept these stories of the wonderful vitality of certain seeds as untrue until some careful and official test has been made. Travelers returning from the Orient with the seeds of wheat purchased from wandering Arabs or shrewd Eastern hucksters have no higher authority than the word of irresponsible venders that the wheat was taken from some Egyptian mummy some two thousand years old.

But there is a manifest power in certain seeds of retaining their vitality for remarkable periods, and wheat and corn are the most important in this respect. It is even asserted by trustworthy authorities that it is possible for seed corn or wheat to retain their potential life for centuries buried in the ground under the most favorable conditions. It is moreover probable that Nature adopts some such method as this to preserve certain types of plants. There have been insects, diseases, or other causes that have swept certain plants from the face of the earth, or at least from large continents, and after a lapse of ages they have reappeared. The explanation of this is that some of the seeds remained buried in the earth, where they remained dormant until some change in the soil exposed them to the light and heat of the sun. Then their fertility, so long held in check, reasserted itself, and the

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plants once more clothed the surface of the earth. Time and again botanists have discovered the sudden appearance of species of plants heretofore unknown to exist in regions where the flora was carefully examined and classified. If this theory be true, we know not what new species of plants we might be the means of reviving by turning over the deep soil of some swamp or rich piece of upland. There may be unknown possibilities for good or evil that no one can measure today. Hidden away in the deep soil may lie the seeds of plants that have not been seen to flourish since the days of Christ.

It has been demonstrated by actual experiments that many of our wild forest plants produce seeds that, when buried in the subsoil, can retain their vitality for ten, twenty, and thirty years. This is evidenced by the fact that by taking off successive layers of earth from an old swamp or field, new plants will spring up from seeds that must have long been dormant in the earth. Corn and wheat that have been accidentally lost under old buildings, where they were covered with soil, but unable to get a ray of light, have sprung into growth when the buildings were removed.

Some of the state experiment station experts are now making exhaustive tests to ascertain the exact nature of the longevity of seeds. Large quantities of seeds of many of our wild and cultivated plants are selected and put away in suitable places where their vitality will be the most apt to be conserved. Every year a small proportion of each variety of these seeds is tested for their germinating powers. In this way, the average longevity of each species will be demonstrated beyond a doubt. Naturally, it will take many years to make this series of tests of much value, for it is well known that there is great longevity among many seeds, and all that the scientific test can ascertain is the relative or absolute longevity of those used in the experiment.

The difference in the length of life between individual seeds is almost as great as that between species. Individuals of the same species vary in the length of their life in the proportion of 1 to 16, and in the species from 1 to 20. This latter variation is partly guesswork, in view of the scanty knowledge on the subject, and it may be discovered that the period of variation is far greater among the species than we have any reasonable belief today. But scientific conclusions can be drawn only from ascertained and demonstrated facts, and, until we know more about the longevity and vitality of the seeds, positive assertions regarding their wonderful powers of retaining their fertility for generations must be received with some caution.

FORCE OF A BLOW

By the "Professor"

TWO questions that are frequently asked are: With what force will a falling hammer strike? and, With what force will a projectile fired from a gun strike an object? These questions cannot be answered directly, as they are based on a misconception. A moving body possesses kinetic energy, or ability to do work, which can only be expressed in foot-pounds, but not in pounds of force, since the work done by the hammer or projectile in coming to rest is not a manifestation of force but of energy.

Work is measured by the product of force and distance; hence, if the work a body has done or is capable of doing is known, the force could be determined for each case if by some means it were possible to determine exactly the distance in which the work was done. This distance depends on various resistances, such as that due to moving the object struck, the resistance to penetration, friction, the resistance to shearing or deformation of the body, etc. The distance through which these resisting forces act is generally indeterminate, and since the average of the resisting forces varies generally with the distance, this average resisting force is also indeterminate, and hence the force that, acting through a distance, will absorb all the kinetic energy of the hammer or projectile cannot be determined for the reasons given.

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CONSTRUCTING A SHEET-METAL CUPOLA

(*Continued from the August, 1900, Number*)

William Neubecker

LAYING OUT AND CONSTRUCTING THE VENTILATOR—THE VARIOUS TOOLS USED IN THIS AND OTHER WORK ON THE CUPOLA

IN DESCRIBING the method of erection of this cupola, the intention of the writer is to give each step distinctly, commencing at the bottom and finishing at the top, as is done in practice. It will therefore be necessary to give the construction of the ventilator shown above the floor of the cupola, before laying out the columns.

A half elevation and a half structural view of the ventilator is shown in Fig. 12; the principal dimensions, which have been obtained from Fig. 2, are found to be 2 feet 9 inches for the diameter of the vent shaft, and 5 feet for the diameter at the bottom of the flare and the hood. It is customary in practice to lay off the half section only, as shown to the left of the center line *A B*. In this case, however, the half elevation is drawn as well, and is shown to the right of the center line.

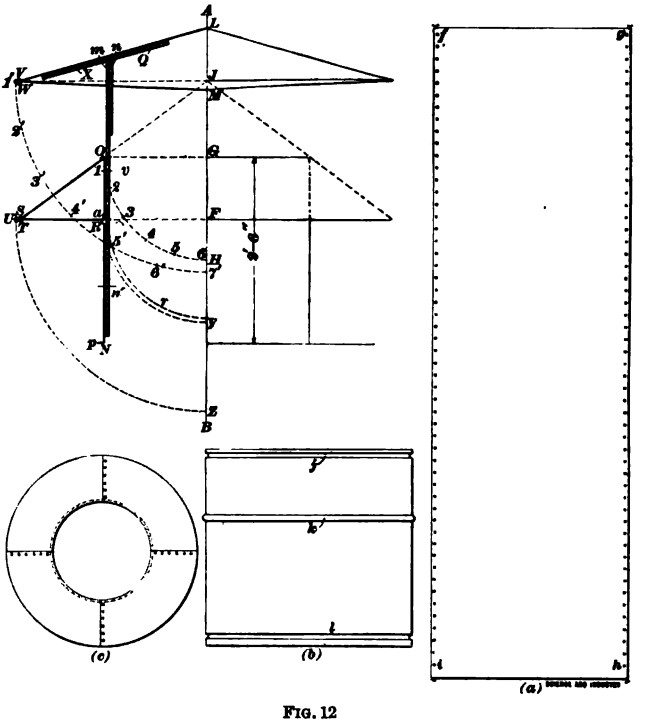

FIG. 12

Referring to the sectional view, *N O* shows the shaft line with a flange stretched outward at *p*, a swage placed at *R*, and a single seam turned over at *O*. *O S* shows the flared piece, which is double seamed at *T*, while *T R* is the flat bottom with a burr at *a*, resting on the swage *R*. The hood *L V* is double seamed to the deflector *W M*, as shown at *W*, and the entire ventilator is thoroughly reenforced and stiffened by the braces *Q X*, six of which are required.

The detail for the ventilator having been drawn, everything is in readiness to get out the work in sheet metal. As the diameter of the shaft is 2 feet 9 inches, its circumference will be 103⅝ inches, or 8 feet 7⅝ inches, which is obtained by multiplying the diameter by 3⅛. Since riveting is required, it will be necessary to add to this length 1 inch for lap, making the entire length of sheet 8 feet 8⅝ inches. From Fig. 2, the height of the shaft from *h* to *g* is found to be 2 feet 6 inches, which dimension is shown in Fig. 12. To this height of the shaft, 30 inches, there must be added 1 inch for the flange required at *p*, and another ½ inch at *O*, making a total of 31½ inches.

The sheet of metal required to form the shaft of the ventilator will then be 31½ in. × 8 ft. 8⅝ in., as shown in the diagram (*a*), Fig. 12, and since 1 inch for lap has been allowed, the center line for the rivet holes can be laid out by scribing the lines *g h* and *f i* ½ inch from the edges of the sheet. At the bottom, where the 1-inch flange will be stretched outward, mark on the lines just scribed *i h* 2 inches from the end; on the top, where the ½-inch flange will be turned, measure downward 1 inch, as shown at *f g*.

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Set the dividers at 2 inches, and mark off points between *f* and *i*, and between *g* and *h*, the distances equal to the pitch of the rivets, as shown in the figure. These holes, as laid

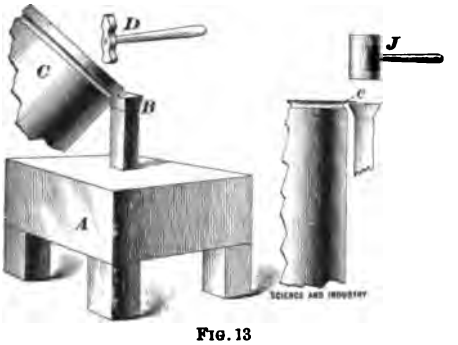


FIG. 13

out, can be punched by using a rivet punch and a small block of lead or hard wood. After the punching has been done, the shaft of the ventilator can be rolled up on the 36-inch rolls and riveted on the mandrel

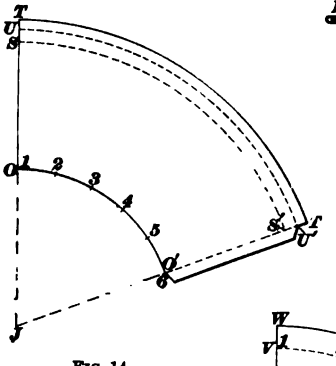
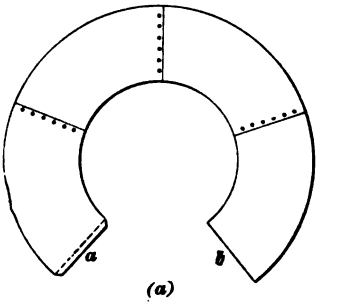


FIG. 14

stake. The pipe thus formed is now taken to the turning machine and run through once or twice, after which process it will have the appearance as shown at *l* in diagram (*b*), Fig. 12. The cylinder is now reversed and the process is repeated at the other end, the groove *j* being formed. By setting the beading machine to a distance equal to *O R* in the section and inserting the end *j* of the cylinder first, and running it through the rolls once or twice, the bead *k* is formed, which is the same as designated at *a* in the section of Fig. 12. The next step is to turn the 1-inch flange at the bottom, which may be accomplished as illus-



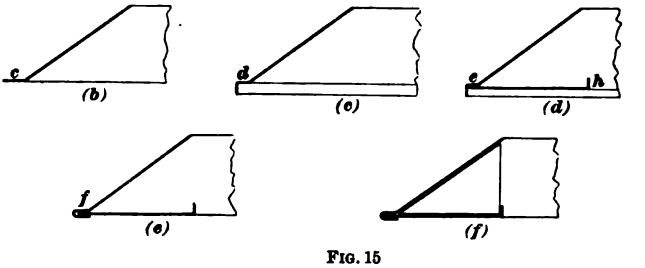
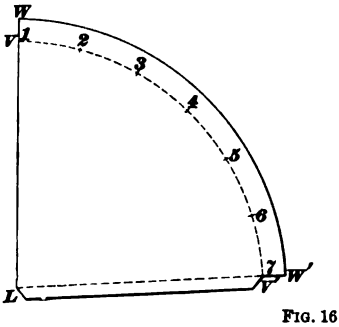


FIG. 15

trated in Fig. 13, in which *A* shows the bench and *B* the "square head."

Sometimes the sheet-metal cylinder has a tendency to assume an oval shape when handled, and in order to avoid this it is often necessary to tack in the cylinder two flat bottoms, cut from old metal, one at each end, which precludes any such tendency



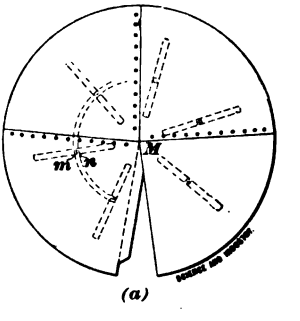


FIG. 16

and keeps the cylinder circular. The pipe is now held in the position shown at *C*, and the flange is laid with the stretching hammer *D* to the position shown by the dotted line *e*. In this operation, the helper

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slowly turns the pipe on the stake while the mechanic strikes blow after blow. The flange is still further turned by using the wooden mallet shown at *J*.

The distance between the columns of the cupola does not allow the completion of the ventilator in the shop, and as it is impracticable to hoist it above the columns and lower it in position, it will be necessary to build the ventilator in sections and put it together on the cupola floor. In passing the vent shaft between the columns it will be necessary to press it slightly oval, for its diameter is somewhat greater than the distances between the columns. It can then be put in place and soldered to the metal-covered floor of the cupola, over the curb *S R*, previously shown in Fig. 11.

The flaring piece and bottom *O S T R*, as designated in Fig. 12, must now be gotten out. With *F* as a center and *F R* and *F U* as radii, describe the arcs *R Y* and *U Z* intersecting the center line *A B* at *Y* and *Z*, respectively. From the same center, describe the edge *r*, which will be turned up as at *a* in the section; then *U R Y Z* will be the one-quarter pattern for the bottom *U R*. Four of this pattern are required, and when cut out they are riveted together as shown in the diagram (*c*). With *G* on the line *A B* as a center and *G O* as radius, describe the quarter circle *O H* and divide it into equal spaces, as shown from *1* to *6*. Extend the line *S O* until it intersects the center line *A B* at *J*. Now draw any vertical line, as *T J* in Fig. 14, and from *J* as a center, with radii equal to *J O* and *J S* in Fig. 12, describe the arcs *O O'* and *S S'* as shown. On the line *O O'*, lay off the stretchout of the quarter circle *O H*, Fig. 12, as designated by the numerals *1* to *6*. From the center *J* draw the line *J O'*, extending it outward to *T'*; *S O O' S'* will then be the one-quarter pattern. Make allowance for the double edges *S U* and *U T* in Fig. 12 by laying off the points *S U T* and *T' U' S'* in Fig. 14 and drawing the respective arcs.

After cutting three more of the same pattern, rivet them together, as shown at (*a*), Fig. 15, and roll on the breakhorn stake and rivet together at *a* and *b*. When this has been accomplished, put the larger diameter of the flaring piece in the turning machine and flange out as much as *T S* in the quarter pattern, when the work will look like *c* in diagram (*b*). Now reverse the flaring piece, running it through the turning machine and obtaining the flange as at *d* in diagram (*c*). Place the bottom *T R* in Fig. 12 as at *h* and

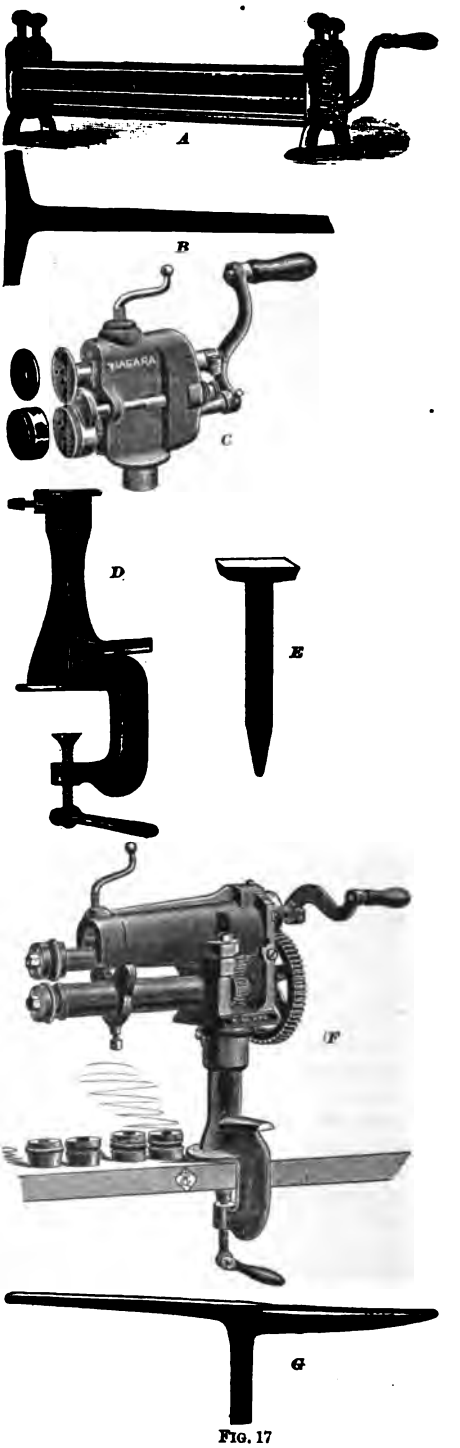

FIG. 17

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e in diagram (*d*), Fig. 15; then double over the flange of the flared pieces, as shown at *f* in diagram (*e*). This portion of the ventilator is now ready to slip over the shaft, except that stays must be provided as shown in (*f*), so that the metal in the pieces will not sag when it is put in place. These stays, six of which are required, are triangular in shape, and are soldered in place.

The flaring piece just completed is slipped over the shaft so that the bottom *T R*, Fig. 12, rests on the swage, or bead, at *a* and the top of the shaft at *O* is then flanged over as shown. The flanging at this point can be accomplished by turning the metal over by degrees with pliers, and working it down with a small hammer to the position shown.

Six braces will be required to support the hood, and should be made of $\frac{1}{4}'' \times 1\frac{1}{2}''$ bar iron. The braces are made as shown in Fig. 12, being bent in the brace bender at the required angle, and bolt holes punched where necessary in order to secure the braces to the galvanized iron and to one another. These braces must be galvanized before being put in place, as otherwise they will rust; the rust, in wet weather, unites with the water and is likely to mar the appearance of the adjacent work by running over it.

The hood and deflector shown by *V L* and *M V* in Fig. 12 must now be laid out and constructed. Draw any vertical line as *L W* on a sheet of metal, as designated in Fig. 16, and with *L* as a center and with a radius equal to *L V*, Fig. 12, draw the arc *V V'*. With *J*, Fig. 12, as a center, and *J W* as a radius, describe the one-quarter plan of the hood and mark the points from *1'* to *7'*, spaced equally. Transfer these spaces to the arc *V V'*, as designated in Fig. 16. Draw a line from *L* to *V'*, and *L V V'* will be the one-quarter pattern for the hood; all edges for double seaming to the deflector are to be allowed as shown. Three similar patterns will be required, and the quarters may then be riveted together, as in (*a*).

The position of the braces must be located on the full pattern, as shown at (*a*), Fig. 16. In order to determine their position, use *M* as a center, and with radii equal to *L n* and *L m* in Fig. 12, describe the arcs *n* and *m* as in the diagram (*a*), Fig. 16. Dividing the two arcs into six equal spaces will give the location of the braces. The hood is now riveted together and flanged as indicated at *V*, Fig 12.

The pattern for the deflector and the position of the braces on it are obtained in a similar manner. When the braces have been located on the deflector, corresponding holes are cut to admit them. When bolting the braces to the hood and shaft, it is well to first bolt the braces to the hood and then drop the deflector into the hood, passing the braces through the brace holes cut in the deflector and forming the double seam at *W*, Fig. 12. The hood is now raised up to allow the braces to slip into the shaft, and is then lowered until the point *W*, Fig. 12, is in line with *J*, the bolts *v n* being then placed and made tight. Where the bolts at *v* enter, it is necessary to cut a small opening in the flare opposite each brace, to admit the bolts, after which it can be closed again by soldering.

In Fig. 17 are shown the various tools used in the construction of the ventilator and elsewhere in the work. At *A* is shown the set of rolls upon which the vent shaft is rolled up, at *B* the stake upon which the shaft is riveted; *C* is the turning machine for flanging, and *D* the machine holder, which is adaptable for several machines; at *E* is shown the "square head," and at *F* the beading machine, while at *G* is seen the breakhorn stake for rolling the flaring collar, hood, and deflector.

(*To be Continued.*)

AN UNRELIABLE INJECTOR

W. H. Wakeman

INJECTORS frequently fail to work as they should, or they may give satisfaction when new, but soon become unreliable, then fail completely and are thrown out of service, all on account of wrong pipe connections.

The accompanying illustration shows the arrangement of piping in a certain plant where the injector would feed the boiler some days, and on others the man in charge found it impossible to get water into the boiler with it. The vertical pipe *a* connected into the head of the upright boiler is $2\frac{1}{2}$ inches in diameter, while all the rest

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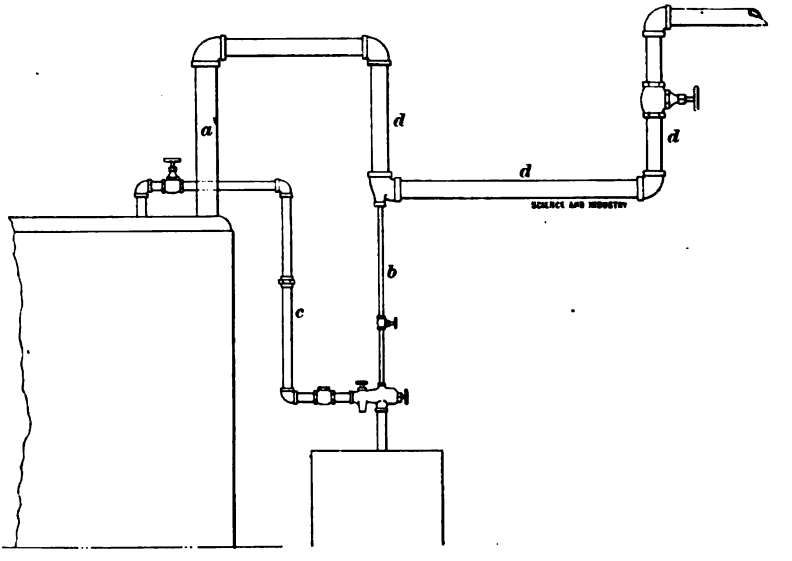
on that line is 2 inches. The small pipe *b* supplying the injector is ½ inch and the feedpipe *c* to the boiler is 1 inch. It will be noted that the 2-inch pipe *d d* forms a trap, and, as none of the pipes were covered to prevent radiation, the water of condensation settled in this trap.

As a rule, small upright boilers prime more or less, and this one was no exception to the general rule. Consequently, the boiler helped to fill the trap with water, and the drip from it, which should have discharged into the sewer, was used to supply the injector with what was supposed to be steam, but in reality consisted of a large percentage of water. An injector needs dry steam for its successful operation, and hence the cause of failure in this case was not difficult to find, when the search was made in an intelligent way. When the draft of steam through the 2-inch pipe was light, the condensation would be excessive, and, consequently, much water would go to the injector. When the draft of steam was heavy, the boiler primed excessively, so that the steam supply to the injector would be about half water, resulting in exasperating failure to feed the boiler at a time when feeding was badly needed. When the amount of steam required was somewhere between these two extremes, its velocity in the 2-inch pipe was sufficient to prevent excessive condensation, and, as the boiler did not prime badly under these conditions, the injector worked perfectly.

I removed all this 2-inch pipe and connected the ½-inch steam pipe for the injector so that it took steam directly from the steam space of the boiler. As the injector was not new, I washed it out with a solution consisting of about 5 parts water and 1 part muriatic acid, the result being an injector reliable every day in the week.



It is always well to locate an injector as close to the boiler as possible; but, if the steam is taken from the upper part of the steam space, and not from the bottom of a large pipe, and the supply pipe is well covered to prevent radiation, it may be placed at any reasonable distance (say not to exceed 100 feet) and still work in a satisfactory manner.

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COMPOUND-WOUND DYNAMOS IN MULTIPLE

Eug. C. Parham

CONNECTIONS FOR PARALLEL OPERATION—THE EQUALIZER—RULES FOR CONNECTING THE EQUALIZER—OPERATION OF THE EQUALIZER

WE HAVE seen that with a shunt-wound dynamo, on account of certain losses that take place within the machine itself, the terminal voltage falls off as the machine's load goes on, and, in order to keep this terminal voltage at normal value and thereby keep the lamps at normal candle-power, resistance must, by means of the field rheostat, be cut in and out of the field circuit accordingly as the lamp load decreases or increases.

The series dynamo has not been taken up at all, because they are not, as a rule, run in multiple; but it is a fact that their terminal voltage, up to a certain limit, increases as the load increases, in spite of the fact that their internal losses increase also. This is

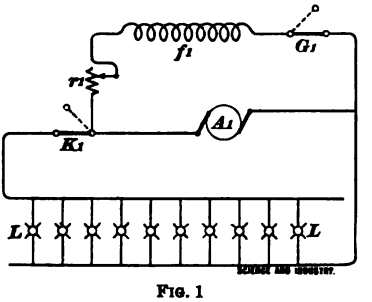

FIG. 1

because all the main-line current must pass through the series field, so that any increase in the value of this current strengthens the field in which the armature turns and necessarily raises the value of the voltage that it can generate.

Since an increase in the load causes the terminal voltage on a shunt dynamo to fall but that on a series dynamo to rise, it would seem to have been a very natural conclusion to draw that the two devices might admit of such a combination as would allow the terminal voltage to neither fall nor rise, but remain the same within certain load limits. The good results of this line of reasoning are to be found in the compound-wound dynamo as it is today. The idea has been carried to a further state of advancement than its first projectors dared to indicate, for the compound-wound dynamo can be made to keep the voltage constant either at its own terminals or at some point out on the line

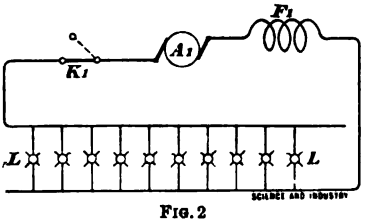

FIG. 2

where the feature of constancy is of more use to the public.

Figs. 1, 2, and 3 are diagrammatic sketches of the shunt-, series-, and compound-wound dynamos, respectively. In all these sketches A_1 is the armature, K_1 is the main-line switch, L is a lot of lamps that represent a part of the outside load; in Figs. 1 and 3, f_1 is the shunt field, r_1 is the shunt-field rheostat, G_1 is the field switch; in Figs. 2 and 3, F_1 is the series field. In all cases, f_1 is wound with a fine wire of high resistance, so that it takes but a small part of the main-line current when in *multiple* with the outside circuit; F_1 is wound with a coarse wire of very low resistance, so that it takes up very little of the voltage when in *series* with

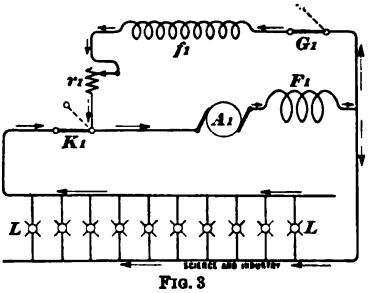

FIG. 3

the outside circuit; the outside circuit is represented by the lamps and their connecting wires.

It is not hard to see that the compound-

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wound dynamo of Fig. 3 is made up from Figs. 1 and 2 superimposed one upon the other. The compound-wound dynamo, therefore, being a mixture of the series and shunt dynamos, has some of the characteristics of both. Like a shunt dynamo it can hold its voltage, even when the main-line switch is open, and, like a series dynamo, cannot lose its field on short circuit, but can, under this condition, throw belts, slip clutches, and cause all kinds of fireworks if the automatic safety devices are at all slow in acting. A shunt machine, for given field and armature connections, runs in the same direction as a motor that it does as a dynamo. The series machine runs in opposite directions in the two cases. In which direction the compound-wound machine will run depends on the relative strengths of its two windings under the conditions governing the occasion of its reversal. When the machine runs as a dynamo, the source of current is in the machine itself, and it passes through the armature and the series field and the shunt field in a certain direction, as shown by the arrowheads in Fig. 3, and the shunt field is a by-path, or shunt, to the outside circuit, or lamp load. As soon as the machine becomes a motor, the source of current is outside of the machine; the condition must be conceived, where, from the outside circuit, there is applied to the terminals of the machine, by means of a dynamo that takes the place of the lamps, a voltage greater than that generated by the machine itself; in such a case the voltage impressed from the outside source overpowers the voltage due to the machine running as a dynamo and backs a current through the machine in spite of the efforts of the voltage of the machine to keep it from doing so. The final result is that the machine is converted from a dynamo into a motor; the voltage that was formerly the E. M. F. of the machine, as a dynamo, becomes its counter voltage, or back pressure, or counter E. M. F., as a motor.

By looking at the arrowheads in Fig. 3, it will be seen that the effect of reversing the flow of current by means of the greater imposed outside E. M. F. would be to reverse the flow through the series field and the armature, but the flow through the shunt field would be in the same direction as before. It is not hard to see, then, since a motor's direction of rotation depends on the relative polarity of its armature and fields, and since this relative polarity, in turn, depends on the direction of the current flow around the respective coils, and, further, in the case in hand, since the current flows around the shunt and series coils in opposite directions, that the two windings in this case are of opposing polarities, and therefore try to urge the armature around in opposite directions. The winding that is the stronger under the conditions imposed will dictate the resultant polarity of the field and thereby dictate the direction of rotation.

The above departure may strike the reader as somewhat irrelevant to the subject in hand, but future developments may change his mind. As is the case of a shunt dynamo, the fact that the fine-wire field of the compound-wound dynamo may be entirely independent of the position of the main-line switch well adapts the machine to be thrown into multiple with other machines of its kind. When so disposed, however, the following points must be borne in mind: When a compound-wound machine is to be run as a dynamo, either alone or in multiple with others, its shunt and series fields must be so connected that they help each other. There is little or no chance of getting the shunt field permanently connected wrong, for in such a case the dynamo could not be made to "pick up" its own field; but there is a chance to get the series field connected in end for end, in which case the dynamo will "pick up" and hold its field on open circuit. When the line switch is closed, however, and it is tried to make the dynamo take a load, it will refuse to do so, because as soon as the main current starts to go through the series windings, their reversed magnetizing force opposes that of the shunt winding, with the result that a part of the properly directed field magnetic lines of force is neutralized so that the voltage is pulled down.

If the dynamo so connected is alone on the load, there will be no other manifestation than inability to make it take its load; but if the dynamo is thrown on to a load already fed by other dynamos, the demonstration is apt to be more violent, as will be shown later. When compound-wound dynamos are to be run in multiple, the instability of their series fields calls for the use of a special device, known as the *equalizer*.

A great many people have a vague idea as to what an equalizer is and what it is used for, but not so many have even a vague idea as to how it does its work. The object of the equalizer is to make possible what would otherwise be impossible under ordinary conditions: the running in multiple of two or more compound wound dynamos whose arm-

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atures are not rigidly connected. The equalizer, under all conditions save one, can be made to regulate several compound-wound dynamos running in multiple so that each will take its share of the load and will do its share of the work. If the dynamos are of the same size and make, the equalizer, if of the right size, can make them share their loads perfectly. If the dynamos are of the same make and therefore of the same general design but not of the same size, the equalizer may be able to look after them without the aid of any other device, and again it may not be able to. If the dynamos are not only of different sizes but of different makes, it may be that the equalizer can be of little use except at great expense. Each of these conditions will be taken up.

To begin with, let us suppose that the two dynamos are as nearly alike in every

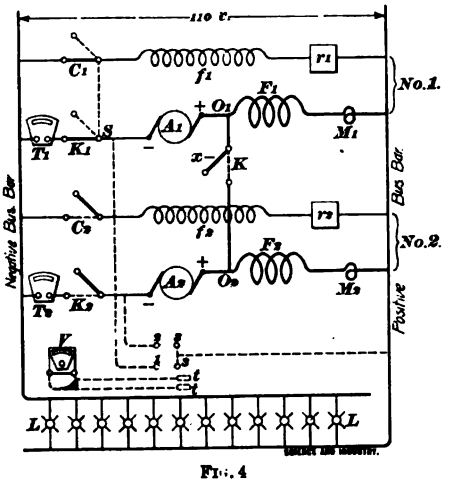

FIG. 4

respect as it is possible, without extraordinary effort, for one maker to turn them out. In such a case, the machines will be of the same output; they will be composed of about the same quality of iron or steel, and the resistances of their respective internal copper parts will be about the same; also they will run at the same speed.

The equalizer looks after minor variations in speed due to defective governing, so that within narrow limits the speed item is cared for. Before delving into the function proper of the device, let us see how it ought to be connected and what means there are for being certain that it is connected that way, and also how its presence affects the *modus operandi* of throwing a machine into or out of service with others.

In Fig. 4, A_1, F_1, f_1, r_1, C_1, and K_1 are, respectively, the armature, series field, shunt field, field rheostat, field switch, and main-line switch of a compound-wound dynamo that we will call the No. 1 dynamo; A_2, F_2, f_2, r_2, C_2, and K_2 are the same, respectively, on a dynamo that we will call the No. 2 dynamo. O_1 O_2 is the equalizer, which is nothing more than a stout bar or cable of copper, with a switch K cut into it at some point, such as x, to throw the device into or out of service, as occasion may require; L is a lot of lamps representing a part of the outside load. The bus-bars are heavy bars of copper to which like terminals of all the dynamos go; the lines to the different parts of the service are tapped on to this common source of supply. M_1 and M_2 are automatic circuit-breakers, one for each machine; each machine has also an ammeter T_1, T_2. Last, a voltmeter V is arranged so that the voltage on any dynamo in the station or the voltage on the line can be read. In Fig. 4, if the voltmeter plugs are shoved into plug holes *1* and *3*, the meter indicates the voltage on the No. 1 dynamo; in holes *2* and *3* it indicates the voltage on the No. 2 dynamo. The voltmeter is always put where it can be seen when the dynamo tender is adjusting any of the field rheostats.

In Fig. 4, the series-field end of each dynamo goes to the positive bus-bar; the other end of each dynamo passes through its main-line switch to the negative bus-bar. The equalizer runs from the series-field brush on one machine to the series-field brush on the other. It does not matter how many dynamos there are in use, all of those on the same load have their series-field brushes connected through a switch to a third heavy copper bar called the *equalizer bar*.

In Fig. 4, the two series-field brushes to which the equalizer runs are shown as the positive brushes, because, as a rule, this is the case in actual practice; but if the two series-field brushes were both negative brushes, the equalizer would work just as well. The cast-iron rule to be laid down in regard to connecting the equalizer is that it shall in all cases go to the series-field brushes, and, further, that the series-field brushes shall be of the same sign—all positive or all negative. To insure that they shall be of the same sign, a voltmeter must be used as follows: With both line switches open and both shunt fields excited, hold the volt lines across both pairs of

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brush holders, one pair at a time; if on the first pair tried the voltmeter needle should deflect to the wrong side of the zero mark on the scale, reverse the points of application of the volt lines so that the needle will throw on to the scale. The polarity of the voltmeter connecting posts is generally marked on the meter itself.

Assuming that the needle throws right, it may be certain that the positive brush holder is connected to the positive post and the negative one to the negative post. With a piece of chalk, mark the sign of the series-field brush holder. Now go to the next machine, find the polarity of its series field brush and mark it. If the signs of the two series-field brushes are the same, the final connection of the ends of the equalizer is in order. If the voltmeter used should have no marks to distinguish the positive and negative posts, tie a knot in one of the test lines and proceed as before to try each machine. If, when the needle throws on the scale, the same voltmeter line rests on the series brush in both cases, it shows the series brushes to be of the same sign and therefore in condition to receive the ends of the equalizer. If the two series-field brushes should prove to be of unlike sign, it would result in a short circuit through the armatures of the two dynamos when their line switches were closed. If the equalizer should run from the series-field brush on one dynamo to the main-line switch brush on the other, the result would be a short circuit as soon as the equalizer switch was closed, even were both main-line switches open. In the first case, the trouble is caused by the two armatures being thrown in series instead of in multiple through the local path F_1–M_1–M_2–F_2–A_2–K_2–T_2–T_1–K_1–A_1–F_1. Both circuit-breakers being in, one of them might fly out in time to avoid serious trouble, but if the equalizer switch happened to be in, creating a short circuit through the path A_1–O_1–K–O_2–A_2–K_2–T_2–T_1–K_1–A_1, the only hope of speedy relief would lie in the weakness that shunt dynamos have for dropping their fields on short circuit; for it must be borne in mind that if K is closed, not only are the circuit-breakers cut out of action, but so are the two series windings, so that the machines cannot hold a field on short circuit.

In the second case, the trouble is caused by both sides of the same dynamo being brought together through the equalizer; for, in Fig. 4, suppose that the equalizer is run from the series brush of the No. 1 dynamo to the main-line switch brush of the No. 2: in this case there would be a dead short circuit through the path A_2–F_2–M_2–M_1–F_1–O_1–K–A_2. If the equalizer were run from the series-field brush of the No. 2 dynamo to the main-line switch brush on the No. 1, the short circuit would take place through the path A_1–F_1–M_1–M_2–F_2–O_2–K–A_1. In either case, it is only necessary to close the equalizer switch to make trouble, because in both cases one of the armatures with its series field is short-circuited through the series field of the other dynamo, and the short-circuited dynamo, acting as a simple series machine on short circuit, can generate a powerful current even if all the shunt-field switches are open. In case the equalizer is so connected, either dynamo can be run alone on the load, if the switch K is left open. However, upon any such symptoms showing up, the matter should be looked into at once and the trouble righted. If the use of both machines is absolutely necessary until such time as the load will permit one of them to be cut out, then cut out both of the series windings, leave K open, and run the two dynamos together as simple shunt dynamos with hand regulation.

In case the equalizer is run between the two series-field brushes, as it ought to be, but one of the series-field brushes is of the wrong polarity, the polarity of the dynamo must be reversed. If the shunt field on the faulty dynamo is connected across the bus-bars as shown in Fig. 4, the line voltage dictates the polarity of the dynamo, so that it cannot develop the wrong sign unless its fields are connected wrong, in which case the dynamo will refuse to pick up its own field when on the load alone. Why this is has been explained in another article. If, however, the shunt field, instead of being connected across the line and thus in a way separately excited, is connected on the inside of the main-line switch at some such point as S, Fig. 4, the machine then becomes self-exciting, in which case it is liable to sign reversal that may not be found out until it causes trouble. To reverse the polarity of the machine, we will say for the present, until future developments show a better way, lift one set of brushes (all the positive or all the negative) or disconnect one of the armature leads so that the current cannot reach the armature, and throw in the main-line switch K_1. If the No. 2 dynamo is running, it will send a current through f_1 and charge it to the right polarity. The main-line switch must, of course, be opened before the armature circuit is again completed; if it is not,

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and the No. 1 dynamo is standing still, it will not be long in starting as a motor, and perhaps too in the wrong direction.

When testing the polarity of the brushes, preparatory to installing the equalizer, do not let the voltmeter needle deceive you. Some voltmeter needles have a mean way of sticking on the wrong side of the zero mark, and they always stick at a time when the fault is apt to cause trouble. For instance, in one case the needle will throw to the right side of zero, and when the voltmeter lines are removed it will, of course, fly back to zero; but instead of stopping at zero, it goes to the other side and sticks there. If the tester does not happen to notice this, the next time the lines are applied, the needle shows a reversed polarity, whether the polarity is reversed or not, because the small current that goes through the instrument has not power enough to start it. The result is that the tester acts according to the misleading indications, and the next thing he knows he is dodging pulleys and belts and whatever else may happen to be flying around his way. This weakness that many voltmeters and ammeters have, has caused a great deal of trouble, all of which could have been easily avoided by simply tapping the meter with the finger before relying on its reading. The tester should always satisfy himself that none of his instruments stick.

It ought to be safe to assume now that, with the knowledge in hand, the equalizer is connected to the proper brush holder and that the brush holders are of the same sign, as shown in Fig. 4. In order to better realize the great advantages of the equalizer, let us see what happens when it is tried to run two compound-wound dynamos together without an equalizer. Let the equalizer remain intact, but let its switch K stay open, so that the device cannot act. Suppose both dynamos to be in circuit and to be running along smoothly on a certain load that is equally divided between them. Now, suppose that, for some reason or other, the voltage generated by, say, the No. 1 dynamo drops a little. (It may drop because the engine to which the dynamo is belted or clutched drops a little in speed; or it may drop on account of a belt or a clutch slipping, or because the machine's shunt field heats up a little faster than the shunt field on the No. 2 dynamo, or because a slight difference in the construction or material of construction, or the position of the brushes on one of the dynamos enables it to generate a slightly higher voltage at a given load than its mate can.) The part of the load that each dynamo will take depends on the voltage that it generates; this, in turn, depends on the strength of the shunt and series fields. As soon as the voltage goes down a little, then, let it be due to whatever cause it may, the No. 1 dynamo shirks a little of its load; the current through its series coils becoming less, their ability to supply magnetism becomes less, so the voltage goes down still more and the machine loses more load. In the meanwhile the No. 2 dynamo has acquired more than its share of the load; its series-field is therefore strong and its voltage well up. The very fact that the load on the No. 1 dynamo has gone down and that on the No. 2 dynamo up, tends to again equalize the potentials on the two machines and cause them to share the load more evenly, because if the No. 1 dynamo's voltage went down in the first place on account of an overload that caused its belt or clutch to slip or its steam engine to slow down, the assumption of a part of the load by the No. 2 machine relieves the No. 1 machine and allows it to get back into normal condition; but the chances are that it does not get so much relief until the undue load thrown on the No. 2 machine causes its belt to slip, or something of the sort to take place, and so the load seesaws from one machine to the other, first one belt or clutch slipping and then the other. If the load is such that neither machine, when running normally, is anywhere near full load, there is lots of margin for variation, and no particular harm can come from the seesawing effect, aside from the fact that it is a very uneconomical way to run. Also, a good dynamo tender would never allow two half-loaded machines to stay on the load when one fully loaded one would be a great deal more economical. When, however, the total load is such that both machines are somewhere near full load, they cannot be run without an equalizer with any success, because the swell-like variations in load result in heavily overloading first one dynamo and then the other, with the final result that there is wicked sparking at the brush holders, occasionally flashing over from one holder to the other, and wholesale slipping of belts.

If the belt flies off a machine, as they often do, its dynamo, being still in electrical connection with the line, has a current backed through it and is run as a motor, perhaps in the opposite direction to what it has been running as a dynamo. In such a

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case, the only thing that can avoid disaster is quick action on the part of the circuit-breaker. To emphasize the effect of the seesaw action that takes place between two dynamos that may be run in multiple without any equalizer connection, it can be stated that the two dynamos can be so run without any great amount of demonstration if the belts on both machines are loose, so that they can slip freely. Under this condition, if for any reason one machine takes a little more load than the other, its belt begins to slip, the speed of its armature drops, its voltage goes down, and it loses some of its load, which is then taken by the other dynamo, which goes through a similar cycle of operations, finally resulting in the slipping of its belt. So the load goes on, changing from one dynamo to the other, neither dynamo being allowed to get up to full load nor down to no load, for as soon as any kind of load comes its way its belt slips and dumps it, while as soon as its load gets down anyway low, the other machine dumps the load back on to it again.

It is not hard to see that two machines so run, while actually demonstrating that they can be run without an equalizer, would be of very little commercial use, because, aside from the fact that constant slipping of a belt is a very bad thing for the belt itself, it is impossible to get anywhere near the full load of one machine on to both of them—a very uneconomical condition under which to run. It would be much better to shut down one machine altogether and put all the load on the remaining one. It is very interesting to watch the ammeters on two dynamos so belted; first one and then the other goes up and down. As a final resort, where the natures of two dynamos are so different that they cannot be run together, even with the equalizer, it is the custom to divide the circuits so that each machine can look after a part or all of the load, according to the demand.

Now let us suppose that with the connections given in Fig. 4, that the No. 1 dynamo is on the load and that there is a sudden demand for the No. 2 machine. Under this condition the K_1 and C_1 switches are closed and the M_1 circuit-breaker is, of course, in. To switch in the No. 2 machine, close C_2, adjust the voltage on No. 2 to 110 volts by means of the field rheostat r_2, close the equalizer switch K and right after it the main-line switch K_2. If everything is as it should be, the load will immediately divide itself equally between the two dynamos, if, as has been supposed, they are alike in every respect. More often than not, the two dynamos will not be exactly alike in every respect, with the result that first one and then the other will carry a little more load than its mate. It is, however, very often the case that an apparent unequal distribution of load is due to neither dissimilarity in the dynamos nor to lack of efficiency in the equalizer system, but to a difference in the reading of the two ammeters that are supposed to be alike but as a matter of fact are not. Ordinarily, these ammeters should be compared about once a year with an ammeter that is known to be correct. In case the instrument is subjected to the effect of an unusually prolonged short circuit through it, it should be checked up at once. Such inequalities in reading are more apt to occur on ammeters that read the drop from a standard resistance (called a *shunt*) than on those through which the whole current flows; because, in the first case, since the reading of the meter depends on the relative resistance of the meter circuit and the shunt, any slight change in either will affect the reading; a bad joint or a blow to one of the shunt wires from a workman's tool will change the relation. In the second case, it does not matter how many bad or loose joints there are in the meter circuit; if the current can flow at all it must go through the meter, which tells exactly how much is flowing. When a series ammeter is off in its readings, the trouble must be looked for in the instrument itself and not in its connections.

Let us suppose that the meters and everything else are in good order, and see what takes place when the equalizer switch is closed. It is not very hard to see that the effect of closing switch K is to put the series coils of the two dynamos in multiple, i. e., the equalizer O_1 O_2 is in series with field F_2 and the two in series are in multiple with field F_1 of the active machine, so that the current leaving armature A_1 on reaching point O_1 has two paths by which to reach the + bus-bar. Part of it takes the path O_1–F_1–M_1 through the series coils of the No. 1 machine, and part of it takes the path O_1–K–O_2–F_2–M_2. Bear in mind that the line switch K_2 on the No. 2 dynamo is yet open, so the No. 2 dynamo can send no current; but the No. 2 dynamo has voltage, due not only to the fact that its shunt field has been adjusted to give 110 volts on open circuit, but also to the fact that part of the current from the No. 1 dynamo passes through its series coils. The closing of K then robs

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the F_1 series field of a part of its current and gives it to the F_2 series field, with the result that the No. 1 dynamo's field being thus weakened, its voltage goes down, but the No. 2 dynamo's field being strengthened, its voltage goes up.

A current cannot flow between two points unless those two points are at different potentials, any more than water can flow between two points unless those two points are at different levels or pressures. The end O_1 of the equalizer is at a higher potential than the end O_2, so a current flows from O_1 to O_2 to the + bus-bar, and in doing so passes through F_2. As soon as the main-line switch K_2 is closed, the No. 2 armature becomes active and the dynamo takes a part of the load. As soon as this takes place the potential throughout the path T_2–K_2–A_2–F_2–M_2 is raised and so is that of point O_2. The potential of the whole line is raised, because each machine is able to look after its own field and neither is robbed. In other words, as soon as the load going through each machine is the same, the drop in voltage through each takes place at the same rate, corresponding parts of the two machines being alike, and it is not long before the two ends of the equalizer are at the same potential, and current ceases to flow through it. In this condition, the load is said to be equalized. Let the voltage now, for some reason or other, drop a little on the No. 2 dynamo. There will at once be a redistribution of the voltage—a kind of shifting along the circuit, as it were, of the voltage in the No. 2 dynamo's circuit; in other words, the total voltage generated by the dynamo being less than it was before, but the number and succession of points for it to drop through being the same, each point cannot command the same pressure it did before the drop, so the pressure on the O_2 end of the equalizer falls and current again flows from the No. 1 dynamo to the field of the No. 2 dynamo, brings up its voltage, and makes it take more load. If for any reason the voltage should drop on the No. 1 dynamo, the potential of the O_1 end of the equalizer would fall and allow a flow of current to take place from the No. 2 dynamo to the series field of the No. 1 to bring up its voltage and once more equalize the load.

However, a little thought and a look at Fig. 4 will show that there is a limit of voltage variation beyond which the equalizer is unable to keep up the voltage of the lagging machine. The maximum current can flow from one dynamo through the series field of the other, when the latter's line switch is open, in which case, if the resistance of the two fields is the same and that of the equalizer is so small that it can be neglected, the current divides into two equal parts, one part going through the field of each dynamo. The only condition under which more current than this can pass from one to the other is when the voltage on one machine becomes so low that it is unable to look after its load at all, in which case the line voltage backs a current through the dynamo and runs it as a motor. Between these limits the equalizer will equalize the loads, but it cannot hold the voltage on the line at its normal value, because the act of equalization, beyond certain limits, pulls down the line voltage by diverting current from one machine to the other, where it will not be sustained by as much support from the shunt winding. As soon as the line voltage goes down at all, it means that not so much pressure is applied to the terminals of the shunt windings, so that the field strength and voltage contributed by those windings becomes less.

To state the condition from another point of view: In order for the equalizer to do its work right, it is necessary, when the machines are under load, that some current value less than the current that will flow from the leading machine to the field of the lagging one, when the leading machine is under full load and the line switch on the lagging machine is open, be sufficient to restore the voltage on the lagging machine to its normal value. If the voltage on the lagging dynamo, for some cause or other, gets so low that an equalizing current equal to one-half the total current that flows when one machine is under full load, will not furnish magnetism enough to the lagging machine to restore its voltage to normal value, the virtue of the equalizer is gone, so far as maintaining constant line voltage is concerned, and the lagging machine acts like a simple shunt-wound dynamo. It is a comfort to know, however, that such a great disparity in the voltages is not apt to occur unless there is something very unusual the matter. Such a condition of affairs can be brought about by opening the shunt-field switch on one of the dynamos, or by breaking one of its shunt-field wires. A condition just as demonstrative will be brought about if the steam is shut off one of the engines without cutting out the dynamo belted to it.

(*To be Continued.*)

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BELTS AND BELTING

J. A. Grening

FINDING THE LENGTH OF BELTS—WIDTH OF BELTS AND HORSEPOWER TRANSMITTED—CARE OF BELTS—FLAPPING—LACING BELTS

A BELT is a flexible connecting band that drives a pulley by its frictional resistance to slipping at the surface of the pulley. Belts are most commonly made of leather, cotton, or rubber, and united in long lengths by cementing, riveting, or lacing.

Leather belts are made single and double. A single belt is one composed of a single thickness of leather; a double belt is composed of two thicknesses of leather, cemented and riveted together the whole length of the belt.

Cotton belts are in use to some extent, as are also belts made of a number of layers of duck sewed together and impregnated with a preparation rendering them waterproof. These belts, in accordance with the number of layers, or "plys," are called two-ply, three-ply, etc. Four-ply cotton and duck belting is about equal to single leather belting, and eight-ply to double leather belting.

Rubber belts are especially adapted for use in damp or wet places; they will endure a great degree of heat or cold without injury, are quite durable, and are claimed to be less liable to slip than leather belts.

In practice, the necessary length for a belt to pass around pulleys that are already in their position on a shaft is usually obtained by passing a tape line around the pulleys, the stretch of the tape line being allowed as that necessary for the belt. The lengths of open-running belts for pulleys not in position can be obtained approximately as follows:

RULE I.—*The length of an open-running belt equals 3¼ times one-half the sum of the diameters of the pulleys plus twice the distance between the centers of the shafts.*

Let D = diameter of one pulley, in inches;
D_1 = diameter of other pulley, in inches;
L = distance between centers of shafts, in inches;
B = length of belt, in inches.

Then,

$$B = 3\tfrac{1}{4}\left(\frac{D + D_1}{2}\right) + 2L.$$

EXAMPLE.—The distance between the centers of two shafts is 9 feet 7 inches; the diameter of the large pulley is 36 inches, and the diameter of the small one is 14 inches; what is the necessary length of the belt?

SOLUTION.—Applying Rule I, and substituting the values given, we have, since 9 feet 7 inches = 115 inches,

$$B = 3\tfrac{1}{4}\left(\frac{36 + 14}{2}\right) + 2 \times 115 = 311\tfrac{1}{4} \text{ in.},$$

or 25 ft. 11¼ in. Ans.

The length of crossed belts cannot be determined by any simple calculation.

A belt should be wide enough to bear safely, and for a reasonable length of time, the greatest tension that will be put on it. This will be the tension of the driving side. The safe tension for single belts may be taken as 60 pounds per inch of width, single belts averaging $\frac{3}{16}$ inch in thickness. The tension on the driving side, however, does not represent the force tending to turn the pulley. The force tending to turn the pulley, or the *effective pull*, is the difference in tension between the driving side and the slack side of the belt. The tension on the driving side depends on three factors: the effective pull of the belt, the coefficient of friction between the belt and pulley, and the size of the arc of contact of the belt on the smaller pulley.

The effective pull that may be allowed per inch of width for single leather belts with different arcs of contact (the arc in which the belt touches the *smaller* pulley) is given in the following table:

Arc Covered by Belt.		Allowable Effective Pull per Inch of Width. Pounds.
Degrees.	Fraction of Circumference.	
90	.25	23.0
112½	.312	27.4
120	.333	28.8
135	.375	31.3
150	.417	33.8
157½	.437	34.9
180 or over	.5	38.1

The arc of contact in degrees or as a fraction of the circumference can be determined practically as follows: Stretch a string over the two pulleys, to represent the belt. Then take another string, and, wrapping it around the small pulley, cut it off so that the ends meet; this represents the circumference of the

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small pulley. Now, take a third string and holding one end at the beginning of the arc of contact, as shown by the string stretched around both pulleys, wrap this third string around the smaller pulley and cut it off at the end of the arc of contact. The length of this last string represents the length of the arc of contact. We now have the proportion: the length of the string representing the circumference : the length of the string representing the arc of contact : : 360 (the number of degrees in a circle) : the number of degrees in the arc of contact; whence the number of degrees in the arc of contact equals the quotient obtained by dividing the product of the length of the arc of contact and 360 by the circumference of the pulley.

To obtain the fraction of the circumference, divide the length of the string representing the arc of contact by the circumference.

To use the table for finding the width of a single leather belt for transmitting a given number of horsepower, we have the following rule:

Where C = allowable effective pull (from table);
H = horsepower to be transmitted;
W = width of single belt, in inches;
V = velocity of belt, in feet per minute.

RULE II.—*Multiply the horsepower to be transmitted by 33,000, and divide this product by the product of the velocity of the belt and the allowable effective pull, as taken from the table. The quotient will be the width of the belt.*

Or, $$W = \frac{33{,}000\ H}{V\ C}.$$

EXAMPLE.—What width of single belt is needed to transmit 20 horsepower, the arc of contact on the small pulley being 135°, and the speed of the belt 1,500 feet per minute?

SOLUTION.—According to the table, the allowable effective pull for 135° is 31.3 lb. Then, applying Rule II, we have

$$W = \frac{33{,}000 \times 20}{1{,}500 \times 31.3} = 14 \text{ inches, nearly.}$$

The horsepower that a single belt will transmit is given by the following rule:

RULE III.—*Multiply together the effective pull taken from the table, the width of the belt in inches, and the speed of the belt in feet per minute. Divide the product by 33,000.*

Or, $$H = \frac{C\ W\ V}{33{,}000}.$$

Speed of Belts.—By applying Rule III to the same belt running at different velocities, it will be seen that the higher the velocity, the greater the horsepower the belt can transmit, and from Rule II it will be seen that the higher the speed of the belt the less may be its width to transmit a given horsepower. From this it follows that a belt should be run at as high a velocity as conditions will permit, the maximum velocity allowable for a laced belt being about 3,500 feet per minute for ordinary single and double leather belts. For belts spliced by cementing, where the splice is practically as strong as the belt itself, the velocity may be as high as 5,000 feet per minute. Cases are on record where wide main belts have been run at as high a velocity as 6,000 feet per minute.

In choosing a proper belt speed, due regard must be paid to commercial conditions. While a high speed of the belt means a narrow and consequently a cheaper belt, the increased cost of the larger pulleys that may be required may offset the gain due to the high belt speed, at least as far as first cost is concerned.

For illustration, let the problem be to transmit 10 horsepower from one shaft to another; let the revolutions of both the driven and the driving shaft be equal, and let the shafts make 200 revolutions per minute. Choosing a belt speed of 2,000 feet per minute, the width of single belt to transmit the given horsepower will, by Rule II be, say, 4½ inches. The diameter of pulley, which at 200 revolutions per minute will give a belt speed of 2,000 feet per minute, is $\frac{2{,}000 \times 12}{200 \times 3.1416} = 38\frac{1}{4}$ inches, nearly. Taking the price of a 38-inch cast-iron pulley, 5-inch face, as $15, the price of two pulleys will be $30. Let the distance between the pulleys be 20 feet. Then, the length of belt, according to Rule I, is 50 feet 4 inches. Taking 51 feet as the length of the belt, and the price of a single leather belt 4½ inches wide at 50 cents per foot, the price of the belt will be $25.50. Then, cost of belt and pulleys, not counting freight or express charges, etc., will be $25.50 + $30 = $55.50.

Choosing a belt speed of 3,500 feet per minute, the width of belt will be 2½ inches, nearly. The proper diameter of pulley is $\frac{3{,}500 \times 12}{200 \times 3.1416} = 66\frac{7}{8}$ inches, say 67 inches. The length of the belt will be 59 feet, about. The price of the belt at 30 cents per foot is $17.70. The price of two 67-inch pulleys of 3½-inch face is, say, $80. Then, total first cost is $80 + $17.70 = $97.70, showing that in

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this particular case the use of a low belt speed reduces the first cost by \$97.70 — \$55.50 = \$42.20.

The above illustration is not intended, and must not be construed, to be an argument against high belt speed; it simply shows the advisability of considering the commercial features in each and every case. In many cases it will be found that the narrow high-speed belt is by far the more economical one to use.

Double belts are made of two single belts cemented and usually riveted together their whole length, and are used where much power is to be transmitted. As the effective pull for single belts as given in the table is based primarily on the strength through the lace holes, a double belt that is twice as thick should be able to transmit twice as much power as a single belt, and, in fact, more than this, where, as is quite common, the ends of the belt are cemented instead of laced. Where double belts are used on small pulleys, however, the contact with the pulley face is less perfect than it would be if a single belt were used, owing to the greater rigidity of the former. More work is also required to bend the belt as it runs over the pulley than in the case of the more pliable single belt, and the centrifugal force tending to throw the belt from the pulley also increases with the thickness. Moreover, in practice it is seldom that a double belt is put on with twice the tension of a single belt. For these reasons, the width of a double belt required to transmit a given horsepower is generally assumed to be seven-tenths the width of a single belt to transmit the same power. On this basis, Rules II and III become, for double belts:

RULE IV.—*To find the width of a double belt, multiply the horsepower to be transmitted by 23,100. Divide this product by the product of the velocity of the belt and the allowable effective pull, as taken from the table.*

Or, $$W = \frac{23{,}100\,H}{V\,C}.$$

RULE V.—*To find the horsepower that a double belt can transmit, multiply together the effective pull taken from the table, the width of the belt, and its velocity. Divide the product by 23,100.*

Or, $$H = \frac{C\,W\,V}{23{,}100}.$$

EXAMPLE.—What width of double belt is required to transmit 20 horsepower, the arc of contact on the small pulley being 135°, and the speed of the belt being 1,500 feet per minute?

SOLUTION.—According to the table, the effective pull is 31.3 pounds. Then, by Rule IV,

$$W = \frac{23{,}100 \times 20}{1{,}500 \times 31.3} = 10 \text{ inches, nearly. Ans.}$$

EXAMPLE. — What horsepower can be transmitted by a 6-inch double belt, running at 400 feet per minute, with an arc of contact of 180°?

SOLUTION.—According to the table, the effective pull is 38.1 pounds. Applying Rule V, we have

$$H = \frac{38.1 \times 6 \times 400}{23{,}100} = 4 \text{ H. P., nearly. Ans.}$$

It is a much disputed question as to which side of the belt should be run next to the pulley. The more common practice is believed to be to run the belt with the hair, or grain, side next to the pulley. This side is harder and more liable to crack than the flesh side. By running it on the inside, the tendency is to cramp or compress it as it passes over the pulley, while if it ran on the outside the tendency would be for it to stretch and crack. Moreover, as the flesh side is the stronger side, the life of the belt will be longer if the wear comes on the weaker, or grain, side. The lower side of the belt should be the driving side, the slack side running from the top of the driving pulley; the sag of the belt will then cause it to encompass a greater length of the circumference. Long belts, running in any other direction than vertical, work better than short ones, as their weight holds them more firmly to their work.

It is bad practice to use resin to prevent slipping. It gums the belt, causes it to crack, and prevents slipping for only a short time. If a belt in good condition persists in slipping, a wider belt should be used. Sometimes larger pulleys on the driving and driven shafts are of advantage, as they increase the belt speed and reduce the strain on the belt. Belts may be kept soft and pliable by oiling them once a month with castor oil or neat's-foot oil.

One of the most annoying troubles experienced with belting of all kinds is the violent flapping of the slack side. Flapping may be due to any one of several causes, or a combination of them. The most usual cause of flapping is that one or both of the pulleys run out of true. The belt is then alternately stretched and released, and, while this may not cause flapping at one speed, it will usually do so at a higher speed. If the belt is rather slack, tightening it somewhat may

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cure or alleviate the flapping. The most obvious and best remedy, but the most expensive, is to turn the pulleys to run true.

Pulleys being out of line with each other are another prolific cause of flapping, especially when one or both run out of true. First, bring the pulleys in line; if this fails, tighten the belt, if rather loose. If no improvement is noticed and it is not possible to turn the pulleys, try to lower the belt speed a little, either by the substitution of smaller pulleys or by changing the speed of the driven shaft, according to circumstances.

With belts running at speeds above 4,000 feet per minute, flapping may occur when the pulleys are perfectly true and in line with each other, even when the belt has the proper tension. This is believed to be due to air becoming entrapped between the face of the pulley and the belt. At any rate, it has been observed that perforating the belt with a series of small holes will cure this trouble. Perforated belts may now be bought in the market. Lack of steadiness in running, due either to sudden variations in speed of the engine or to sudden changes in the load of the machine driven by the belt, will produce a flapping that is almost impossible to cure. The only known cure is to take such steps as will insure steady running, as, for instance, increasing the weight of the flywheel on the engine, or placing a flywheel instead of a pulley on the driven machine. The belt not being joined square will also cause flapping, especially when the belt is running at a rather high speed. The remedy is to unlace or unfasten the joint and make it square. Too great a distance between the pulleys may also cause flapping. In general, the distance between

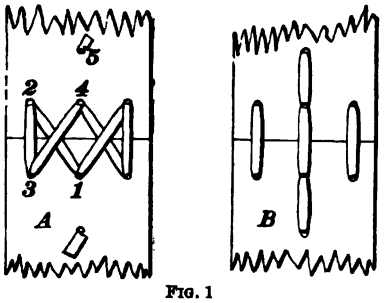

FIG. 1

the pulleys should not exceed 15 feet for belts up to 4 inches; 20 feet for belts above 4 and below 12 inches; 25 feet for belts above 12 inches and below 18 inches; and 30 feet for larger belts. The distances here given are occasionally exceeded considerably, and, as no experiments have ever been made public which would enable a fairly correct formula to be deduced for the distance between pulleys, when the belt speed, width

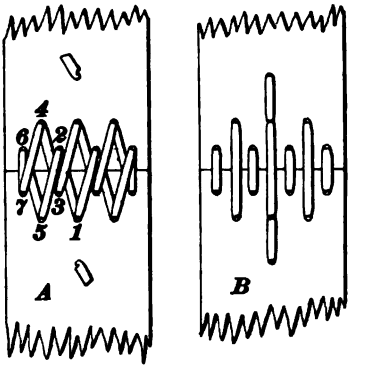

FIG. 2

of belt, and effective pull are known, they must be taken as representing average practice.

A horizontal belt is considered by many to have the proper tension when it has about 1 inch sag while in motion for every 8 feet between the pulleys. For belts other than horizontal, this should be less, no sag at all being necessary for vertical belts. The ends of the belts may be joined by lacing, sewing, riveting, or cementing.

There are many ways of lacing belts in use. A very satisfactory method for belts up to 3 inches in width is shown in Fig. 1. Cut the ends of the belt square, using a sharp knife and a try square. Punch a row of holes according to the width of the belt, punching corresponding holes exactly opposite each other in each end of the belt, using 3 holes up to 2 inches, and 5 holes above 2 and up to 3 inches. The number of holes in the row should always be uneven for the style of lacing shown. In the figure, *A* is the outside of the belt, and *B* the side running next to the pulley. To lace, the lacing should be drawn half way through one of the middle holes from the under side, as at *1*. Before going any further, it is well to see to it that the belt has no twists in it, or, in case of a crossed belt, that it has not been given a wrong twist. The same side of the belt should run over both pulleys, which will be the case with a crossed belt if it has been twisted correctly. Having made sure that the belt is fair, pass the end of the lace on the upper side of the belt through *2*, under the belt and up through *3*, back again through

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2 and *3*, through *4*, and up through *5*, where an incision is made in one side of the lacing, forming a barb that will prevent the end from pulling through. Lace the right-hand side in the same manner. The lacing may advantageously be carried on at once, to the right and left alternately.

For belts wider than 3 inches, the lacing shown in Fig. 2 is a good one. As will be observed, there are two rows of holes. The number of holes in the row next to the joint should exceed by one the number of holes in the second row. For belts up to 4½ inches, use 3 holes in the row next to the joint, and 2 holes in the second row. For belts up to 6 inches, use 4 and 3 holes, respectively. For larger belts, make the total number of holes in each end either one or two more than the number of inches of width, with the object of getting an odd total number of holes. For example, for a 10-inch belt, the total number of holes should be $10 + 1 = 11$. For a 13-inch belt, it should be $13 + 2 = 15$ holes. The outside holes of the first row should not be nearer to the edge of the belt than ¾ inch, nor should the first row be nearer to the joint than ¼ inch. The second row should be at least 1¾ inches from the end. In the figure, *A* is the outside and *B* the side next to the pulley. Begin at one of the center holes in the outside row, as *1*, and continue through *2*, *3*, *4*, *5*, *6*, *7*, *4*, *5*, *2*, *3*, etc.

Another method is to begin the lacing on one side instead of in the middle. This method will give the rows of lacing on the under side of the belt the same thickness all the way across. The lacing should not be crossed on the side of the belt that runs next to the pulley.

Lacing affords convenient means of shortening belts when they stretch, and of increasing their tension. If the belts are at all large, the ends of the belt should be drawn together by belt clamps.

Cementing makes, probably, the best kind of a joint ever devised. It has the serious disadvantage, however, that the stretch of the belt cannot be taken up readily, and hence tightening-pulleys must be used when the center-to-center distance of the pulleys is not adjustable. In dynamo driving, where endless belts are used to the exclusion of all others, the dynamo is usually mounted on a slide, so that the tension of the belt can be adjusted. For a cemented joint, the ends of the belt should be pared down with a very sharp knife. Warm the belt ends near a fire, apply the belt cement while hot, and press the joint together by two boards, one on top and one on the bottom. Belt cement can be obtained of any dealer in engineers' supplies, and full directions for using the cement will always be found on the can. These directions should be implicitly followed.

If belt cement cannot be obtained, a good cement may be made by melting together over a slow fire 16 parts gutta-percha, 4 parts india rubber, 2 parts pitch, 1 part shellac, and 2 parts linseed oil, by weight. Cut all ingredients very small, mix well, and use while hot.

New leather belts will stretch from ¼ to ½ inch per foot of length, and hence must be taken up until the limit of stretch has been reached. Rubber belts are said to stretch continuously. Cotton and duck belts, it is claimed, will not stretch with use. When rubber belts are used, animal oils or animal grease should never be used on them. If the belt should slip, it should be lightly moistened on the side next to the pulley with boiled linseed oil.

DELINEATING A SPIRAL STAIRWAY

Morris Williams

THE architectural draftsman should be able to show on his elevations and sections the true appearance of stairways. Straight stairways are easily enough pictured, but when it comes to geometrical stairs with wreathed stringer and hand rail, the problem offers some little difficulty.

The outline of the hand railing shows more clearly and effectively the shape and twist of the stairway than any other feature of the construction. It is, therefore, necessary that the projection of the wreath should be correct. What we desire to attain is the appearance of the railing in projection, an exact view when the railing is in position over the winders as it twists and wreaths around the cylinder of which the plan of the stairs forms the base. We are especially speaking of a spiral stairway, and shall deal in this article altogether with such.

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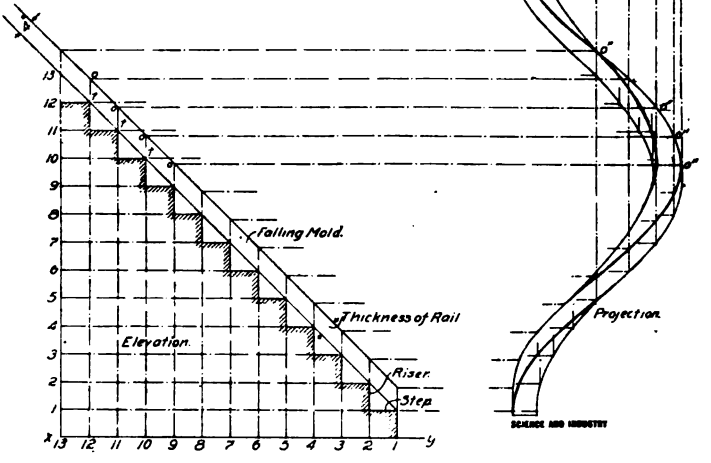
Not only is it necessary for the architect to show a correct view of such a stairway in the elevations or cross-sections of the building, but if the draftsman has laid it out incorrectly, any deformity that may exist in the work can be easily remedied by altering the location of the risers on the plan. If, on the other hand, the view of the projection is pleasing, he can be satisfied that the stair is properly constructed and that the arrangement of the risers will secure satisfactory results when the railing is completed and in position.


Width of Rail
Plan
Falling Mold.
Thickness of Rail
Elevation.
Riser.
Step
Projection
13 12 11 10 9 8 7 6 5 4 3 2 1 x
13 12 11 10 9 8 7 6 5 4 3 2 1 y

In the figure we have a drawing of the plan, elevation of the steps with falling mold, and the projection of the rail for a spiral stairway. The line xy, or ground line, is the exact length of the center line of the rail on the plan, unfolded or stretched out. The numbers *1*, *2*, *3*, etc. along the line xy represent the width of treads on the center line of rail in the plan. On point *13*, or x, draw a perpendicular line, and on this line lay off the height of the thirteen risers, marking the divisions *1*, *2*, *3*, etc. From each point on xy draw perpendiculars, and from each point on the perpendicular line from *1* to *13* extend horizontal lines intersecting the vertical line from xy at the corresponding points. These points of intersection will give the elevation of the steps, and by drawing a line touching the nosing of each step, the "nosing line," as it is called, is obtained. At a distance equal to the thickness of the rail, draw a parallel line to the nosing line. This completes the elevation of the steps and the falling mold. To project the rail, divide the falling mold by vertical lines into the same number of equal parts as are in the plan. In this case, there are thirteen divisions, which correspond to the number of risers in the cylinder. From points o on the falling mold, draw horizontal lines, and from the points o on plan, drop vertical lines intersecting the horizontal lines at o'' in the projection of the rail. The points of intersection will be contained in the curve of the outside top edge of the rail. The inside top edge is found by drawing vertical lines from the inside of the rail on the plan at points i to intersect with the same horizontal lines. To find the outside and inside bottom edge, draw horizontal lines from points t on the falling mold to intersect with the vertical lines from points o and i on the plan, and thus the projection is completed.

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THE HEATING TRADE

Thomas E. McNeill, Heating Engineer

PAST AND PRESENT PRACTICE AMONG HEATING ENGINEERS, WITH SOME HINTS IN REGARD TO THE REQUIREMENTS OF THE FUTURE

SOME progress has been made in steam heating of buildings within a few years past, but much yet remains to be done by the designers as well as by the executors of such work. However, we are moving in the right direction, and in time will be nearer perfection. Both need more thorough training in the best theories and their practical application to the work to be done. Mistakes are to be expected, but they are not confined to the humble members of the craft. The "big lights" largely differ from the proven facts and results, and their rules and practice for proportioning parts and appliances sometimes vary as much as 50 per cent. These so-called rules, therefore, are regarded by many practical men as mere suggestions. Considerable latitude must always be allowed for variations in conditions and circumstances, and good clear judgment, based on practice, must always predominate in final decisions.

The task of a critic is seldom a pleasant or profitable one, for, if he is true and honest, he must boldly say what appears to him to be unbiased and correct, and, in doing this, some one is likely to become offended; but without criticism faults would remain unexposed, error be promoted, and progress delayed.

All changes are not improvements, nor is it well to make changes until we are very sure that they are improvements; but to follow the one way because it is the old way would bar all progress. Often the records of failures are equally as instructive as those of success. The best test of a designer's faith in his own work is his willingness and ability to execute that work, taking the chances of efficiency when completed and of profit or loss in competition with others. Throwing the burden on other shoulders, with their guarantee to back it, is not true engineering.

It is an easy and safe way to call for too much, but the skilled engineer requires and provides for sufficiency and efficiency without redundancy. Only by a comparison of results can true tests be made and intelligent direction be obtained. The designer of a gun may be a very learned man, but "the man behind the gun" is the one who finds out and proves its good or bad qualities. Fault finders are not always fault menders, but it is only by constant comparison that the best results are obtained.

The progress of steam heating of buildings has been slow, for its birth and true development has been within the past 60 years. From very low pressures—just above the atmosphere—it has gone up to very high pressures, but now it is back to even below the atmosphere. Many causes have operated to produce these fluctuations, among them the necessity for power for modern improvements. Reforms do not often come from above, but usually from below. There is an awkward time coming for many; the modern system of teaching is rapidly revolutionizing everything. Criticism will not then come from above stairs but from below, and will be based on actual tested facts instead of on speculative theory. The professor now tells us what ought to be, but the clear-headed student who works with his hands by day and studies by night will want to know why theory and practice often do not work harmoniously, and will ask where the difficulty lies, which of them are in the wrong, and how best to unite them. These questions will come back to the commercially inclined engineer of the present day, who thinks more of his profits than of the cost or success of his work. It may then be a little embarrassing for him to reply intelligently. The engineman and he who shovels the coal will want to know not "How much is there in it for me?" but why should they have to labor so much. They will wonder whether there is not a better, easier, and cheaper way for all; why there should be noisy pipes in the building; where the trouble begins; why the pipes are below, in the way, along the walls and floors, of small size, crooked, and contrary to all theory and practice for easy and prompt water flow; why they are not run overhead, straight, free to expand, ample in size and easy for return water to flow, with plenty of room to work them into place.

The heating engineer will have to deal with accomplished facts—fine-spun theories

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or old prejudices will not do any longer. He will realize that it is not what he thinks ought to be, but what *is*, that will decide matters. The days of speculative experimenting at the expense of others must end, for this horny-handed son of toil will not only thoroughly know what he is talking about, but will prove the correctness of his assertions.

Then the "rule-of-thumb" man who has been working on theories founded on doubtful information—unwritten and often misconstrued so-called facts—who knows only one way of doing everything and thinks it would be criminal to depart from it, no matter what changes may have occurred, will surely be greatly disturbed. He will want to know "how and why" the fireman can ask him questions he never heard before, answer them, and prove their correctness. He thinks it is all wrong, some way, but fails to see the streak of light that has come at night to the willing worker determined to better his condition, and who truly appreciates and blesses the source of it.

Many of those engaged in steam heating are commercial men who have drifted into it, regarding it as merely "pipe twisting," leaving out the engineering requirements entirely. Work executed under such direction, aided or often injured by the foggy experience of the traditionary and belated steam fitter, must be largely guesswork and sadly defective. They too, when confronted by the bright, young, thinking, reading and studying engineer, will have puzzling questions to answer, and if they are not prepared for them they must plead ignorance. The day of awakening has come, and *all* must be up and doing. Ignorance is no longer bliss.

If the master plumbers and their workmen are required to show their proficiency by work and examinations, for the safety of the public health, why should not the master steam fitters and their workmen be required to be licensed also? for the public safety as well as health is endangered when they fail to provide proper ventilation.

INTERCOMMUNICATING TELEPHONE SYSTEM

A. G. Baldwin

SUGGESTIONS FOR THE IMPROVEMENT OF A COMMON BATTERY CALL SYSTEM PREVIOUSLY DESCRIBED—DIAGRAM OF CONNECTIONS

TWO intercommunicating telephone systems, one for magneto call and one for a common battery call, were described in the December, 1899, issue of SCIENCE AND INDUSTRY. A short time ago I had occasion to install a similar system with twelve stations, using the common battery call. Connected up in the manner described in that article, it worked very nicely so far as transmission was concerned, but I found the trouble that the operators at the different stations would continually forget to return the selective switch back to the normal, or home, contact when through talking, with the result that two or more bells would be thrown into parallel circuits, so that the normal battery power would not be sufficient to ring so many bells at once. Then, again, it would interfere to a certain extent with the transmission of the sounds, in some cases being so faint as to make it difficult to distinguish them, which was caused by the instruments being practically short-circuited by the switches throwing in too many parallel circuits.

Thus, referring to Fig. 2 of the December issue, Station 2 is set to call Station 1. Now, if the switch of Station 3 were left on either contact *1* or *2*, the current from the battery *C. B.*, on reaching the proper point, would divide and a part of it go through the bell at Station 3, thus throwing Stations 1 and 3 in parallel circuits; if there were other stations whose switches were connected with these same lines, the current would still further divide, leaving still less to ring the bell at Station 1. With this system, much more battery power than ordinarily required to ring the bells will be necessary.

I was requested to overcome this difficulty in some way, and have done so in part. I changed the wiring in the manner shown in the accompanying illustrations. In Fig. 1, the common return wire is connected to the

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binding posts c_1, c_2, and c_3 of the telephone sets, which correspond to c in Fig. 2. Each line wire is connected to the contact point of its home station on the selective switch, and thence to the binding posts b_1, b_2, b_3 of the telephone sets. Thus, line *1* is connected to contact point *1* and also to binding post b_1 at Station 1, the battery wire being connected to the double-contact push button the same as before. An extra binding post was then put on the telephone sets a_1, a_2, a_3, etc., and to this was connected one terminal of the secondary of the induction coil; this is shown at a in Fig. 2. The wire leading from the binding post a is connected to the normal, or upper, contact point at the double-through switch HS and contact point J. The bell is in the circuit by being placed between post b and the line wire, or it may be connected between binding post b and the contact point J. The bell connections are not shown. When the receiver is taken from the hook switch HS, the connections between binding posts c and b are broken at J, and the binding posts c and a are connected through HS and contact point h to receiver R, secondary S of the induction coil, and binding post a, thus throwing the receiver and secondary of the induction coil into the circuit and cutting the bell out. This also closes the local circuit of the transmitter T, local battery

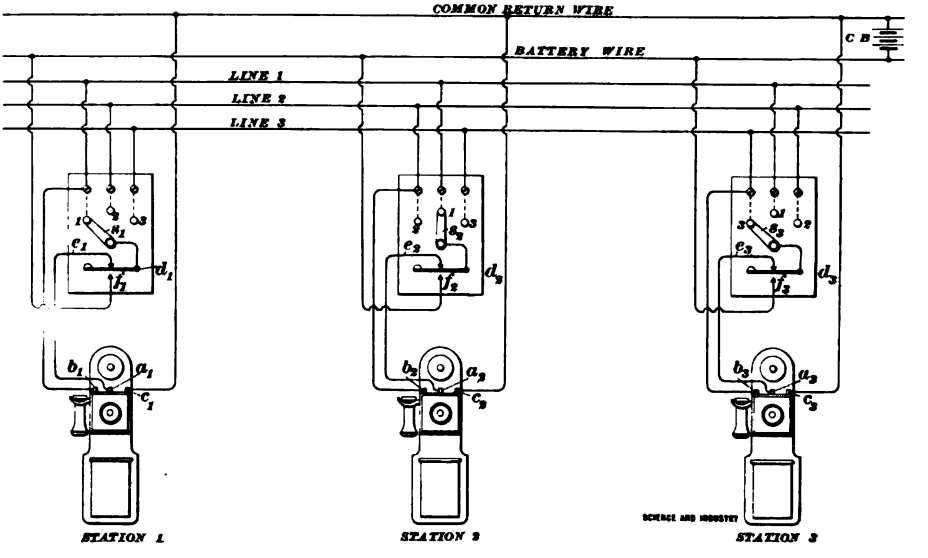

FIG. 1

contact push button, as at e_1, e_2, e_3, Fig. 1, thus connecting the binding post a and the secondary of the induction coil normally with the selective switch, as will be seen by tracing it out in Fig. 1.

Fig. 2 shows a diagram of the connections inside the instrument; a, b, and c are binding posts corresponding to those shown on the telephone sets in Fig. 1; LB is the local battery; at P are shown the connections to the primary coil; S is the secondary coil of the induction coil; T, the transmitter; R, the receiver; R_1, the binding posts for the receiver connections; and HS, the hook switch. It will be noticed that when the receiver is on the hook, the talking apparatus is cut out from the line, the binding posts c and b being connected together LB, and primary P of the induction coil through the contact point g and the switch HS.

Station 2 (see Fig. 1) desiring to call Station 1, places the selective switch on contact point *1* and presses the double-contact push button, thus closing the circuit of the common battery CB at contact point f_2. The course of the current may be traced as follows: From battery CB through battery wire to f_2, d_2, switch s_2, contact *1*, line *1*, bell and binding post b_1 at Station 1, c_1, and common return wire back to battery CB, thus ringing the call bell at Station 1. When the receivers are taken from the hooks, the circuit may be traced as follows: From the binding post a_2 at Station 2 to e_2, d_2, s_2, contact *1*, line *1*, contact *1* at Station 1, switch

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s_1, d_1, e_1, a_1, c_1, common return wire to binding post c_2 at Station 2.

In case Station 3 should have left the selective switch on either contact point *1* or *2*,

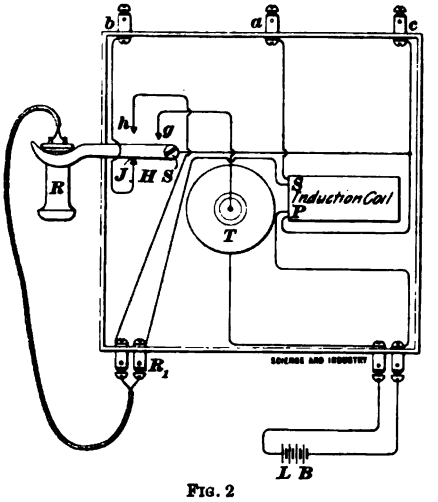

FIG. 2

it would make no difference so long as the receiver at Station 3 remained on the hook, nor would the bell at Station 3 be rung, for the line *1* or line *2* circuit is open at Station 3 between binding posts a_3 and c_3, and, moreover, the bell is not in this circuit. Even if the receiver at Station 3 were off the hook, it would not interfere with the ringing of the bell at Stations 1 or 2, because throwing the receiver and induction coil into the circuit would introduce so much resistance that only a very small portion of the battery current would pass through them, the resistance being about 325 ohms in the instruments I am using.

This system is still open to objection from the fact that the selective switch of the station called must be on the home contact point before any conversation can be carried on, though it does not interfere with the call bell if it is not; but an operator, knowing that fact, on trying to answer a call and getting no response, will naturally look to the switch to see whether it is set right, whereas if he goes away and leaves his switch off there is nothing to remind him of the fact unless he happens to glance at it.

There may be a better or a simpler method of making the connections to attain the same end; but I find that this method works well so far, and causes less trouble and confusion than the other system, and can recommend it where a battery and call bell are to be used for so many stations, and it is not desired to maintain a central station.

EDUCATIONAL PROGRESS

REASON FOR THE ESTABLISHMENT OF TRADE AND TECHNICAL SCHOOLS—WHAT THEY HAVE ACCOMPLISHED—CORRESPONDENCE SCHOOLS

IT HAS been but a comparatively few years since trade and technical schools have become a feature of the American educational system, and it will be somewhat interesting to investigate the reason of the demand for them and to know what has been accomplished through them.

College and university courses up to a short time ago consisted entirely of classical and scientific subjects, to the exclusion of the practical and technical side of education. While classical and scientific education is very desirable and even necessary, it was found that something more was demanded —something that would enable the great masses to get such an education as they could apply in their trades and occupations. The old purely theoretical system, it was found, did not train a scholar to apply his knowledge to the practical affairs of everyday life. This may be illustrated by an incident related of a gentleman of fine scholarly attainments who had occasion to lay out a square corner on a piece of land, and, notwithstanding the fact that he had a foot rule and a pole long enough, and could have given the forty-seventh proposition of Euclid without hesitation had he been called on to do so, still he could not reduce it to practice by simply marking off the dimensions of the sides and hypotenuse of any assumed right-angled triangle.

But the demand for some other system of education arose not so much from the dissatisfaction with or objections to old methods as from the necessity of a better education of the great numbers who never got beyond the high school and the still larger number who never reached it. It became a conviction that some system must be devised

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whereby the boys and young men who early left school to learn a trade and support themselves could have some means of learning the theoretical side of their business and thus fit themselves to cope with the new problems that constantly arise in the prosecution of their vocations.

What has been accomplished in this direction is shown by the report of Hon. Carroll D. Wright, United States Commissioner of Labor, whose inquiry as to the status of industrial education was begun by the direction of Congress "for the investigation of, and the report on, the various school systems, and also technical school systems, of the United States and foreign countries." The schools found to exist were of four classes: manual training schools, trade and technical schools, agricultural colleges, and institutes of technology.

Manual training schools may be defined as those in which instruction is given in tool work as an educational discipline. This is sometimes called the Russian method. It is a misnomer, however, for the methods in use in that country are so diverse that they can hardly be said to be the same as those adopted here. The system may be said to have had its origin in Russia, from thence spreading over Europe and finally to America, where it has reached its highest perfection in schools like those of Chicago, St. Louis, Toledo, and Philadelphia, where something more is taught than the mere use of hand tools. These schools are equipped with mechanical appliances of all kinds on a scale that completely eclipses those of any other country.

Trade schools are those in which the primary object is to give an apprentice a practical knowledge of some mechanical trade. Technical schools are a superior class of trade schools, in which are taught the theoretical and scientific principles of a trade. These schools are at their best in Europe, where a thorough training is given in the minutest details of some specialty, as in the German upholstering and dyeing schools, in the latter of which a student is taught the composition of fabrics and how to compute to a fraction the cost of dyeing a given number of yards of material any color. However, some of the American schools are equal to their European prototypes, and some authorities contend that a few are even superior. Among the leading American schools of this class may be mentioned the New York Trade Schools, the Pratt Institute, the textile department of the Pennsylvania Museum and School of Industrial Art, and the New York Institute for Artist-Artisans; while in such institutions as the Cooper Union, the Drexel Institute, the Williamson Free School of Mechanical Trades, the Armour Institute, and others of the same kind, we have the promise of American supremacy in the industrial arts.

Institutes of technology are those schools in which the courses carry with them a professional degree, such as that of civil, mining, or electrical engineer. In these, as well as in the manual training schools, the highest efficiency has been reached in America, there being nothing in Europe to compare with them. The first of these schools is now about forty years old, and from them the movement extended to agricultural colleges and is now transforming the public school system.

In considering these means of education, it should be remembered that they are those adopted for the better education of the masses, but that the number of schools is entirely inadequate for the task. Manual training schools in the United States have been established by some local authority or by private enterprise as an experiment, and since, unlike those of Europe, they have no government aid or supervision, they are of a heterogeneous character—most of them excellent schools, but some few of such an indefinite character that they can be called manual training schools by courtesy only. No attempt was made to take a census of these educational institutions, and hence it will be impossible to give definite idea of the number receiving training in them. The Chicago training schools had 307 graduates in the first eight years of its existence, from 1884 to 1892, and these figures probably are somewhat near the average number of graduates for the best schools, and range from this to almost zero for the smallest. This small number of graduates is due to lack of accommodations for pupils at these schools, and not to the lack of demand for instruction.

The need of the present day is defined by Richard T. Ely, Ph. D., in an essay on the "Economic Aspects of Industrial Training," in which he says: "Industrial training, not for a few, but for all people, for every boy and girl born in the United States, without one exception, is the chief economic demand of our time. Comparatively little is attained by picking out a few here and there and elevating them above the masses by the technical schools. We want to extend the benefits of industrial schools to all alike."

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But how can this desirable state of affairs be brought about? It has been shown by what has preceded that very little has been accomplished in this direction. While it is true that lack of accommodation has been partly responsible for the meager results, the chief obstacle to its accomplishment is the fact that most of our boys must leave school when very young to become breadwinners, and therefore lack the time and means to attend school. For this class there is but one solution of the problem—if they cannot go to the school, the school must go to them; in other words, they must be reached through correspondence instruction. This is the latest phase of education, and one that is not touched on by the commissioner of labor, because the system is one that has been perfected but recently and he was not informed of its methods and success.

The International Correspondence Schools, of Scranton, Pa., which have been the pioneers in this movement, and in a few years have had more students and graduates than all the schools mentioned, have demonstrated the right of such an institution to exist, and, managed as these schools are, they will in a short time do more for the advancement of education than has been accomplished in the past century by other means.

PETROLEUM INDUSTRY IN RUSSIA

THE St. Petersburg "Messenger of Finance" states that English capitalists have recently invested $9,000,000 in the petroleum-producing territory between the Caspian and Black Seas.

Since 1892, when new regulations concerning the petroleum industry were published, more than 30 firms have received permits from the Minister of Agriculture and Crown Domains to engage in the petroleum industry in Russia, and applications are being made for permission to develop the territory on the Apsheron Peninsula, some 300 miles north of Baku, on the Caspian Sea.

This increased demand for fuel caused foreign capitalists to look carefully after the residues, which has resulted in a decrease in the amount of kerosene exported and a greater demand for petroleum fuel at good prices; this increased 900 per cent. during the past 6 years and is still growing, notwithstanding the competition of pit coal and wood. The demand for petroleum fuel from the factories in and about Moscow has more than doubled in 6 years and now amounts to millions of tons annually.

The consumption of liquid fuel on locomotives has increased tenfold in 9 years and on river steamboats fourfold in 11 years, while the consumption of coal increased 113 per cent. and of wood 58 per cent.

In order to meet the demand for liquid fuel, Baku must increase her output from 242,000,000 poods to 360,000,000 poods (3,903,226 tons to 5,806,451 tons), and, in order to supply the increasing demand from the interior of Russia, it will be necessary to increase the output of residues to 8,064,516 tons in the near future. This development will require a further investment of $8,000,000, which must come from foreigners.

The slow development of the export of kerosene is due partly to the fact that Baku finds it more profitable to produce liquid fuel and partly to the competition of the Standard Oil Company; but, unless the export of Russian kerosene is increased, as the demand from the interior is small, the liquid fuel will contain too great a percentage of dangerous volatile products for profitable trade.

The increased production of kerosene is necessary to supply the fuel residues, and, while the same will meet strong opposition from the United States, success is only possible by Russia adopting the Standard Oil Co.'s methods for saving, transporting, and delivering the product, which will require a largely increased capital. It is estimated that the amount of $10,000,000 will be required to successfully compete with the American oil in England alone.

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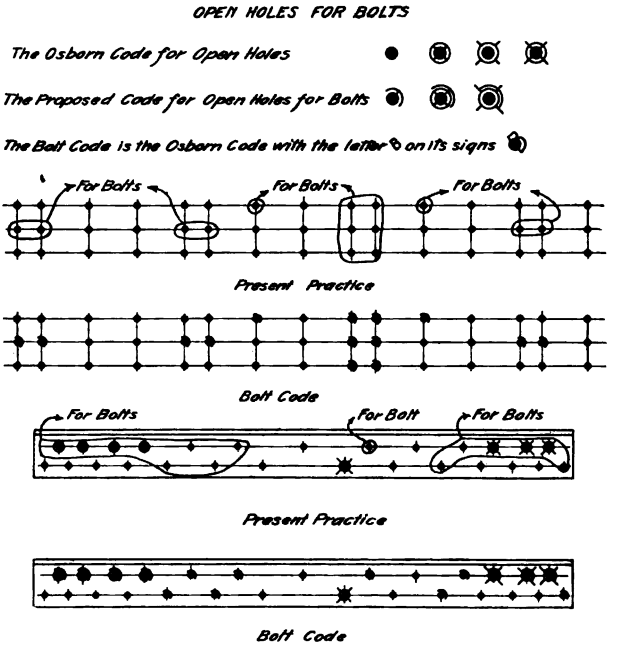
USEFUL IDEAS

A PROPOSED BOLT CODE

We are indebted to Mr. William G. Miller for the accompanying sketches and description of the bolt code, which we have reason to think will be useful to many. He states that it has met with favor among those that have examined it, especially those that are most capable of judging as to its merits. He says in his letter accompanying the drawing: "Every one that has anything to do with the preparation or use of drawings has noticed how unsightly and 'ragged' an otherwise neat looking drawing is made to appear by the use of bolt notices. It is also common experience in the erection of structures to find that the field bolts are often varied from the number required because of the omission of such notices. With a view of correcting some of these troubles, the writer proposes a code for open holes through which bolts are to be inserted. It is simply the Osborn code with the letter *B* on its signs. My code has been shown to a number of persons whose duty it is to get out the field rivets and bolts and they were very much in favor of its adoption on account of its simplicity and the ease with which it can be borne in mind. Some have thought there might be a slight confusion by confounding the bolt sign for plain holes with the Osborn sign for holes countersunk on the far side. In actual practice, however, the position of the open holes in nine cases out of ten will show to the shopman whether the latter is countersunk or for bolts. With the use of well-executed drawings to a reasonable scale and good prints therefrom, little confusion is likely to arise from the code, and it will be found to greatly assist the erector."



Bolt Code Proposed by William G. Miller C.E. Pittsburg, Pa., Oct. 26, 1899

CONCRETE CONSTRUCTION

Jas. L. Karrick, Washington, D. C.

The article on concrete construction in the May, 1900, number is interesting, but it is not entirely definite to me. Would it not be possible for the writer to obtain a detailed statement of methods and cost from the builder or architect, and also the reason for making the change from one method to another? I have just built concrete walls, the first that have been allowed by the building inspectors of this city. The walls with which I had to deal were built from the foundation, at the cellar bottom, to the second-floor joist, bricks being used above that point. The method used in constructing these walls was fairly satisfactory, but I think it could be improved upon.

Boards 12 inches wide were used for the sides of boxes, which had movable ends but were without tops or bottoms. The sides of these boxes were kept from spreading by four $\frac{3}{4}'' \times 18''$ bolts at the bottom, and movable cleats at the top. After the boxes, or troughs, were in place, they were

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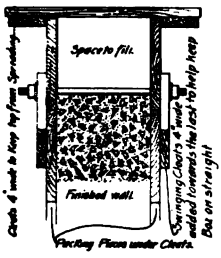
filled with concrete, which was rammed until water showed on the top. This concrete was allowed 3 hours in which to set, when the boxes were taken down by knocking off the top cleats and removing the bolts, the boxes then being set up and used on another part of the wall. There were about 350 feet of wall to be constructed, and we used 8 or 10 boxes. After about 6 hours the wall was hard enough to support the boxes, and then another 10 inches of concrete was added to the height of the wall. The bolts holding the bottom of the sides, being 2 inches from the edge, allowed the boards to lap on the finished wall that distance, the bolts resting on the top of the wall. When the bolts were removed a ¾-inch hole was left, which was easily filled, or pointed, afterwards. The labor cost of making and putting in the concrete, which, of course, does not include the material, was 50 cents per cubic yard, besides one man being required to take down and set up the boxes.

To make a smooth job, we had to work the concrete quite wet, and more sand was used than economy would demand. We commenced operations with 1 part natural cement, 3 parts sand, 4 parts gravel, and 6 parts broken brick, but found the proportions of 1½ of cement, 5 of sand, 2 of gravel, and 6 of broken brick made smoother work.

The advantage of using the apparatus that we employed was that all the material employed in making the boxes could be used afterwards in the building. The disadvantage that we experienced was that, on account of the carelessness of common laborers, the boxes would get knocked out of line, and this would not be discovered until the concrete had set. Of course, with careful supervision this could be avoided.

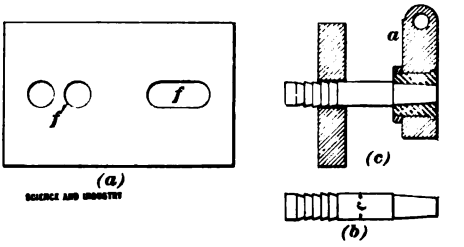

Space to fill
Finished wall
Swinging Cleats 4" wide added towards the last to help keep Box on straight
Packing Piece under Cleats

The accompanying sketch shows the construction of the boxes, and is sufficiently clear to need no further explanation. I consider it an ideal construction for many classes of buildings; for the walls when set are monolithic in nature, offering great stability and durability at low cost. If other readers of SCIENCE AND INDUSTRY have any information on this subject, it would be very interesting to me to hear from them through the columns of this magazine.

BROACHING HOLES ON THE SHAPER

A. Sharper, Waynesboro, Pa.

SOME time ago I had a number of slots, as shown at *f* in view (*a*) of the illustration, to cut into rectangular pieces of steel, the slots being ⅝ inch wide and 1½ inches long, with



semicircular ends. The most obvious way would be to drill two ⅝-inch holes the proper distance apart, as shown at *f'*, and either to plane or slot out the metal between with a regular slotting tool. As such a tool is necessarily slender and springy, it requires considerable time to make a good job of the slotting. After some thought, I decided to make a slotting tool similar to a broach, as shown at (*b*). The front end of the tool was slightly tapered and a number of steps turned in. The tool was then hardened and its tapered rear end inserted into a temporary bushing fitted to the tool-post hole in the clapper *a* of the shaper [see view (*c*)]. The cylindrical part *c* of the tool was made slightly smaller than the largest step, which was made the size of the hole. The clapper being fastened, the slots were then planed. Owing to the slight cut taken by each cutting edge, a nice smooth job was done. The slot was produced quite rapidly, since the sides were planed, or rather broached, to the correct size in one operation. It will be understood that the work was clamped to an angle plate and fed along by means of the cross-feed screw.

Similar broaching tools may be used for shaping hexagonal holes in collars, and other work of the same nature, using a shaper, planer, or slotter.

AN IMPROVED COWL

Frank Humphreville, Atlantic City

THE accompanying sketch shows an improved cowl—one that will not stick. I have tried many different kinds of swinging cowls, but most of them rust and do not move with a slight breeze as they should. I have made a large number of these cowls, and they all give satisfaction. I therefore

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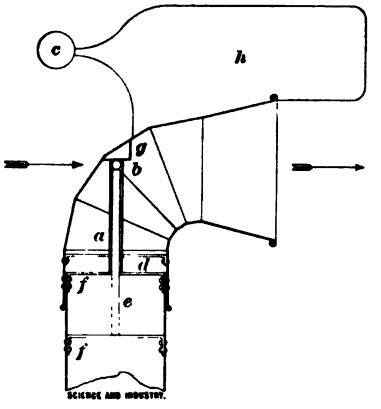
take pleasure in presenting the following description of it for the benefit of the readers



of SCIENCE AND INDUSTRY, trusting that they may get as good results from it as I have.

The water pipe *a* is a piece of galvanized iron; *b* is a ball bearing, which is simply a common marble; *c* is a weight to balance the vane *h*; *d* is a brace to center the pipe *a*; *e* is the center piece of the rod iron supported by braces *f*, *f*; and *g* is the center plate of heavy sheet iron. The pipe *a* is soldered to the plate *g*, and, since the pipe *a* is air-tight, it is impossible for gases to enter it and destroy the bearing. If it is desired to convert the cowl into a down-draft cowl instead of an exhaust cowl, as shown in the sketch, it is only necessary to reverse the vane *h* so that it will keep the mouth of the cowl to the wind with the arrangement shown. The wind blows in the direction of the arrows, and by causing a partial vacuum at the mouth of the cowl, it induces a strong upward draft. When the vane is reversed, however, the wind blows into the mouth of the cowl and produces a down draft.

EDITORIAL COMMENT

ERICSSON TELEPHONE SERIAL

THE Ericsson Telephone Company, of New York, have just issued Part 4 of "The Ericsson Series." It contains some interesting information concerning the number of telephone subscribers in the various large cities of Denmark, Finland, Norway, Sweden, Holland, Russia, China, Egypt, Africa, and South America, that have Ericsson Swedish telephone apparatus and switchboards. It also contains a diagram of connections for a simple metallic switchboard. Any one sending their name and address will receive a copy by return mail.

THE BURT EXHAUST HEAD

IN A modern steam plant running non-condensing, an exhaust head placed on the end of the exhaust pipe is not only a desirable attachment, but in many cases an absolute necessity. As is well known, it serves a double purpose. In the first place, it reduces to a minimum the noise the exhaust steam makes in escaping; in the second place, it removes entrained water and oil from the exhaust steam, and condenses a large part of the exhaust steam, thus preventing constant wetting of the roof or adjoining buildings. As an exhaust head is located in a rather inaccessible place, it should be simple and durable in construction, two conditions that are fulfilled by the Burt exhaust head, made by the Burt Manufacturing Company, Akron, Ohio, who will be pleased to send a full description of the device to any one interested in modern means of reducing expenses about a steam plant.

ENGINEER'S BOOK FREE

EVERY engineer using packing and desirous of keeping up to the times should take the time to send his name and address to the Pilley Packing and Flue Brush Manufacturing Company, 318 North Main Street, St. Louis, Mo., requesting one of their books called "Pilley's Points on Packing." It is well worth $1.00 to every user of packing, and is sent free of cost to all engineers interested. They will also send, for the asking, a very useful memorandum containing eighty pages.

AN AUTOMATIC LUBRICATOR

MR. G. U. MERRILL has designed and patented a positive-feed lubricator intended for grease, which is so constructed that it will feed only when the part to which it is attached is in motion. This is accomplished by the vibration of a pendulum that has a pawl working in a ratchet wheel. The shaft that carries the ratchet wheel has a worm at the end, which meshes with a worm-wheel splined to a central screw carried in a suitable bracket at the top, and bearing on the piston. Any vibration of the pendulum turns the ratchet wheel, which in turn

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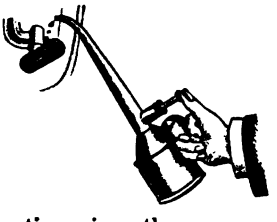
screws the central screw inwards, and the pressure thus produced on the piston expels the grease. Full information in regard to this lubricator will be furnished on application by J. L. Robertson & Sons, Fulton Street, New York, N. Y.

THE CANNON OIL CAN

THE Wallace Supply Company, 56 Fifth Avenue, Chicago, Ill., are furnishing an oil can for the use of engineers which differs considerably in construction from that in common use. With the ordinary can, difficulty is often experienced in getting the oil to flow from the spout, since the force causing it to do so is rather small. In the "Cannon" oil can the oil is pumped by a small force pump, extremely simple in construction, that forms part of the oil can. Owing to the positive displacement of the oil, the can may be used in any position, and is reliable in its action, since the pressure under which the oil can be ejected will remove any obstruction. As shown in the accompanying illustration, the can is operated with one hand with great ease, the plunger of the pump being pressed inward with the thumb to start the oil. More complete details will be furnished on application by The Wallace Supply Company.



COAL, POWER, AND LUBRICANT

PLAIN and practical remarks on lubricants are always of interest and value to users of machinery. Coal burned at one end of a plant and the power obtained at the other end depend on the lubricant used between. An addition of 10 to 15 per cent. of Dixon's pure flake graphite to the oil or grease will enable either to do several times more work.

A good lubricant is a trifle as to its cost, but is not a trifle as to consequences. Consider what a lubricant is for—to save power in machinery. The amount of power lost in machinery is variable; it is always large. It may be fairly estimated that one-half the power expended in the average case, whether in mill or shop, is wasted in lost work, being consumed in overcoming the friction of surfaces. To the large user of power, poor and inefficient lubrication means enormous waste of power and costs for repairs. It has been most thoroughly demonstrated that an oil or grease is necessary for saving power and preventing wear, and that Dixon's pure flake graphite is the only solid lubricant that largely enchances the lubricating value of oils and greases. Furthermore, where this graphite is used, a cheaper or lower grade of oil or grease can be used and the expense of lubrication reduced as well as power saved.

THE DETROIT LUBRICATOR CO.

WE HAVE received the 1900 catalogue of the Detroit Lubricator Company, Detroit, Mich., which contains a full description of a number of specialties that have been added since the last edition of the catalogue. A remarkably clear explanation of the working of a sight-feed lubricator has been inserted, which should prove of benefit to any one who wishes to know "why" the oil flows from the lubricator into the steam-pipe. The practical hints on the care and operation of sight-feed lubricators that appear in this edition should interest and undoubtedly will be appreciated by any one using sight-feed lubricators.

The catalogue contains full descriptions and directions for operation of all the goods manufactured by the Detroit Lubricator Company, who will send it upon request, free of charge. Among the many different classes of goods made may be mentioned sight-feed and plain lubricators, brass and glass oilers and oil pumps, oiling devices, boiler oil injectors, low-water indicators, globe valves, steam and hot-water radiator valves, and balanced throttle valves. The catalogue is standard size, 6 in. × 9 in., and is a handsone specimen of the printer's art.

BOOK NOTICES

THE KNIGHT OF THE GRIP. Being a series of dissertations on his conditions, character, and conduct, as they appear to an ordinary chap who has studied him. Price, cloth, 60 cents. David Williams Company, New York.

This is a book of reminiscences, which, without intending to instruct, gives the traveling fraternity many pointers. There is not a word of advice in it, but nevertheless plenty of advice can be derived from its perusal. It is not humorous, in the sense of being funny, and every incident is taken from life. Every traveling salesman, agent, or solicitor should have a copy.

NOTES ON THE ELEMENTARY FORMS, METHODS OF CONSTRUCTION, AND DIMENSIONS OF COMMON ARTICLES OF FURNITURE. By

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Alvin Crocker Nye, Ph. B., Instructor in Furniture Designing, Pratt Institute, Brooklyn, N. Y.

This is a book suitable for reference to obtain the necessary data for work in connection with furniture designing, particularly in the points of construction. The book is unique, inasmuch as, instead of being filled with illustrations of historic furniture for the designer to blindly copy, the plates show simple skeleton forms of furniture that can be elaborated according to any school or style of design; and the constructions and framing plans being given, there will be no danger of the designs being improperly schemed for production. To the student, the experienced draftsman, and the architect, the book will be a great aid as a textbook and a reference, as well as a source from which to draw ideas for the designs of characteristic furniture.

America's Working People. By Charles B. Spehr. Longmans, Green & Company, New York. Price $1.25.

This book was not written by one who had "an axe to grind" or who had a theory to elaborate; it is a record of the personal observations of the author in all parts of the country—in the East, the South, the West, and the Northwest—and deals with the conditions as found in the sections visited. As the title indicates, the subject treated of is the "working people." A clear account is given of the daily lives of the employed as affected by the conditions governing them, and we are told how they live, the salaries they receive, and their observations regarding matters affecting them. Both sides of the labor question are presented—the employer's and the workman's—but in such an impartial manner as not to arouse a feeling of antagonism on the part of the fair minded reader, no matter what his views may be. It is a very interesting book.

Horseless Vehicles, Automobiles, Motor Cycles, Operated by Steam, Hydrocarbon, Electric, and Pneumatic Motors. By Gardner D. Hiscox, M. E. Norman W. Henley & Co., 132 Nassau Street, New York. Price, $3.00.

Those who have read the earlier works of the author of this book will not be disappointed with this, his latest effort. It is made up very largely of catalogue descriptions and illustrations of nearly every type of motor vehicle that has been introduced in America up to the present time. The general reader who is interested in knowing what has been done in this field, and who cares more for an outline of the leading features of the different types than for accurate technical information, will find much that is interesting and some that is instructive in the pages of this book. The engineer, however, who has given the development of horseless locomotion some study, will find nothing in it that will be new, while the student who wants principles, or the designer who is searching for practical information that will assist in the proportioning of vehicles, or the motors and gearing by which they are propelled, will find that these points are as carefully concealed as they are in the catalogues of the most conservative builders.

Gas-Engine Construction. A practical treatise describing the theory and principles of the action of gas engines of various types and the design and construction of a ½-horsepower gas engine. By Henry V. A. Parsell, Jr., and Arthur J. Weed, M. E. Norman W. Henley & Co., 132 Nassau Street, New York. Price, $2.50.

This is preeminently a book for the amateur, and contains only so much theory as is required to enable the beginner to understand the general principles on which the action of the gas engine depends and the purpose of the various parts that enter into the construction of the more common types of this motor. The descriptive matter is also limited to the illustration of a representative engine of each of the different classes, with a brief explanation of its leading features. The greater part of the space is taken up with directions for the construction of a $2\frac{1}{2}'' \times 4''$ horizontal four-cycle gas or gasoline engine, rated at ½ horsepower. Complete working drawings of all the details, together with very thorough instructions for performing the different operations involved in their construction, are given. The instructions cover all the different steps of patternmaking and machining, and are made particularly clear by means of half-tone reproductions of photographs of the patterns, the methods of fastening the work in the lathe for the different operations, and of the various steps involved in finishing the parts and assembling them. The work is so designed that the only machine actually required in finishing all parts of the engine except the flywheels is a lathe with an 8-inch swing. With this and the requisite small tools, any careful amateur can, by following the instructions given, feel confident that his labors will be rewarded by the production of a successful motor.

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ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*
2. *Only questions of general interest to our readers will be answered.*
3. *No questions will be answered by mail.*
4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*
5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*
6. *Reference to inquiries previously answered should give date of issue and number of question.*
7. *Questions cannot be answered in the issue of the month immediately following their receipt.*
8. *Any book not out of print and for sale by regular dealers may be ordered through the magazine.*
9. *We will not undertake to calculate windings of dynamos and motors, as this involves considerable work and is seldom justified.*

MECHANICAL

(397) Explain a rule for laying out a development of a tapered course for a boiler 40 in. in diameter on its large end, 39 in. on the small end, and 40 in. in height. A. G. G., Two Harbors, Minn.

ANS.—Use the method described in Answers to Inquiries, No. 355, in the December, 1899, issue.

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(398) (*a*) I have a small fine emery wheel, run at a low speed by foot-power, that is to be used for grinding scissors, etc. I have been told that a dry emery wheel will take the temper out of tools; is this the case? (*b*) How hot must a tool become before it is injured? E. S., Egan, Ill.

ANS.—(*a*) There is not the slightest doubt that it is *possible* to draw the temper out of the edges of cutting tools when using a dry emery wheel. However, the very fact of the temper being drawn shows that the wheel is improperly used. The wheel should run at a high speed, about 5,000 ft. surface speed per minute; grind very lightly and you will have no trouble. In machine-shop work, milling cutters, reamers, and similar cutting tools are usually ground with a dry emery wheel without drawing the temper; as a matter of course, using a wet wheel reduces the liability of getting the edges too hot. (*b*) This depends on the purpose of the tool. In general, the cutting edge becomes injured when it is heated to a higher degree than that corresponding to the temper given.

***

(399) Explain the cause of foaming in a boiler and tell how to stop it. O. O. D., Massena, N. Y.

ANS.—The most usual cause of foaming is oil in the boiler, often in combination with other impurities that with the oil form a scum or soapy compound. This rises to the surface of the water and prevents the free escape of the steam, with the result that foam or froth is formed. Some feedwaters contain impurities that produce foaming even though no oil is present. The best remedy for foaming is to keep the boiler free from oil and other impurities that cause it. If it is impracticable to keep all such impurities out of the boiler, a surface blow-off will do much to prevent serious foaming.

***

(400) (*a*) What will be the flow of water through a straight galvanized pipe 10 in. in diameter and 5,000 ft. long, under a head of 5 ft.? (*b*) Give a formula for calculating the flow of water in pipes of different lengths and diameters under different heads. (*c*) Show by a sketch the construction of the inspirator and explain the principles of its action; also give directions for its operation.

V. N., Escanaba, Mich.

ANS.—(*a*) Probably about .85 cu. ft. per second. (*b*) The following are simple formulas for different kinds of pipes, that will give fairly satisfactory results: For rough or pitted cast-iron pipes above 6 in. in diameter, $Q = \sqrt{D^5 h}$; for rough pipes from 3 to 6 in. in diameter, $Q = 0.89\sqrt{D^5 h}$; for new smooth cast-iron pipes, the formulas for large and small pipes are, respectively, $Q = 1.40\sqrt{D^5 h}$ and $Q = 1.25\sqrt{D^5 h}$. In these formulas, Q = flow in cubic feet per second; D = diameter of the pipe in feet; and h = head per 1,000 ft. of pipe. For different degrees of roughness, the flow will vary between the above extreme values. (*c*) We cannot spare the space in these columns for an answer to this question. A very good description of the Hancock inspirator and of the principles of its operation is given in an article in "Home Study Magazine," for September, 1896. A copy of this magazine can be obtained from The Colliery Engineer Co.; price 15 cents. For directions for operating the inspirator, we advise you to apply to the makers.

***

(401) An engine is running at speed down a very steep grade. The reverse lever is thrown into full gear—in the same motion as the engine is running. The steam is at 150 lb. pressure. If, now, the throttle is opened, will it increase or will it check the speed of the train? A. F. W., Gibara, Cuba.

ANS.—This is a question we would rather not answer dogmatically, as we have never tried the effect of giving an engine steam with the lever in full gear at such an extreme speed as you imply. In any case, a great deal depends on the valve gear—whether or not there is any inside clearance. For instance, if speed is not too high, opening the throttle might increase it if the lever were cut well back rather than if full over. On the other hand, speed might be so high that opening the throttle would check it.

***

(402) (*a*) In estimating the horsepower of a boiler, what proportions are allowed for the different styles of riveted joints? For example, a return-tubular boiler has double-riveted lap joints with ¾" rivets properly spaced according to the rules of the Hartford Steam Boiler Insurance and Inspection Co. If this boiler, estimating on a basis of 14 sq. ft. of heating surface per H. P., is rated at 92 H. P., what would its rating be if triple-riveted lap joints were used, and what if inside and outside butt straps with triple rows of ¾" rivets were used

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for the joints? (*b*) We test our new boilers to a hydrostatic pressure of 125 lb. per sq. in. What is the equivalent in steam pressure?

H. W., Selma, Ala.

ANS.—(*a*) The type and strength of the joints make no difference in the horsepower rating. With the second and third types of joints, the boiler would be stronger and would safely carry a higher pressure, but it would not necessarily develop a greater amount of power. (*b*) A hydrostatic pressure of 125 lb. per sq. in. is the same as a steam or air or any other pressure of the same intensity. In order, however, to make sure that a new boiler is strong enough to safely carry the pressure, it is usually tested at a pressure higher than that at which it is to work. A common ratio is to make the test pressure 1½ times the working pressure.

***

(403) I have a water motor with a ¾" jet that is to work under a pressure of 120 lb. per sq. in. The drain from the motor will be 35 ft. long, with a fall of 4 ft. Will a 2" pipe be large enough for the drain; if not, what size should I use?

R. W. T., Honesdale, Pa.

ANS.—We would recommend a 3" pipe. With a smaller drain, there would be danger of flooding the motor and subjecting it to considerable resistance.

***

(404) (*a*) How is the steam space of a water-tube boiler calculated? (*b*) How would ordinary welded pipe stand the action of a steady fire? (*c*) Would threaded connections be all right when only occasional service is required? (*d*) What working pressure would ¾" pipe stand? (*e*) What per cent. of metal could be drilled from hydraulic pipe to leave it with the same working pressure as in case of question (*d*)? (*f*) With rough bands shrunk on a pipe, would both expand evenly enough for the bands to act as stays? (*g*) What substance is best for making threaded joints that are exposed to the fire? (*h*) Is there a simple device for attracting the sediment in a water-tube boiler, or must the boiler be designed for that purpose?

M. M., Toronto, Can.

ANS.—(*a*) Allow about .5 cu. ft. steam space per indicated horsepower. (*b*) We do not think that any boiler inspector would pass a boiler constructed of ordinary welded pipe. Solid drawn tubing should be used. (*c*) Yes. (*d*) Ordinary wrought-iron pipe of this size is tested to 300 lb.; we would not care to allow a higher working pressure than 150 lb. on it. Opinions differ on this subject, however. (*e*) You propose an impracticable scheme. You can get solid-drawn steel tubing of almost any gauge far cheaper than you can bore out hydraulic pipe. (*f*) Yes. (*g*) Graphite. (*h*) The boiler must be designed so that all sediment will collect in a space to be provided for this purpose.

***

(405) (*a*) How do you find the efficiency of a boiler? (*b*) How do you find the size of feed-pump for a boiler? (*c*) Is there any rule to find the size of blow-off? (*d*) Is there any other way of reversing a high-speed automatic engine than to shift the fly-wheel? (*e*) How can the horsepower of an engine be increased without increasing the speed or boiler pressure? (*f*) A boiler is supported by four lugs, two on each side; how can I determine whether it rests on all four lugs, and how can I fix it if it does not?

W. S. N., Denver, Col.

ANS.—(*a*) Divide 100 times the number of British thermal units usefully expended in making steam in a certain time by the number of British thermal units applied in the same time; the quotient will be the efficiency in per cent. (*b*) A common rule is the following: Multiply the horsepower by 35; the product will be the number of pounds of water needed per hour. From a manufacturer's catalogue, select the nearest size of pump. (*c*) No. It may be made any size desired. (*d*) This depends entirely on the design of the engine. (*e*) Increase the mean effective pressure by making the cut-off later or by adding a condenser. (*f*) This can only be determined by actual inspection. Block up one of the low plates below the lugs in order to fix it.

***

(406) (*a*) What is the correct angle for a twist drill? (*b*) Should a flat drill be ground to the same angle? Give me a few pointers about grinding drills.

H. A. W., Salt Lake City, Utah.

ANS.—(*a* and *b*) We presume that you refer to the angle of relief; that is, the angle included between a plane perpendicular to the axis and a plane tangent to the backing off of the cutting edges. This angle must be determined by actual experiment on the metal that the drill is used on, bearing in mind that the angle that gives the easiest cutting drill is not necessarily the angle of greatest durability. Each different metal requires a different angle for best results. For general work, it may be about 10°. The cutting edges may make an angle of 60° with the axis. Flat drills are usually ground to the same angle and backed off as much as twist drills.

ELECTRICAL

(407) A short time ago, a man was killed by a current of 25 amperes at a pressure of 400 volts. A friend of mine said that if the amperes and volts had been more nearly equal this man would not have been killed. Are there any grounds for this statement?

H. A. W., Salt Lake City, Utah.

ANS.—No.

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(408) What causes sparks to form a ring around a commutator?

W. S. N., Denver, Col.

ANS.—Small rings of fire running around a commutator are sometimes caused by dirt or carbon dust becoming lodged between the segments. The rings so formed are comparatively fine and do no great amount of damage. If they appear very numerous, the commutator should be well cleaned off. If there is an open circuit in the armature winding, or a broken connection where the winding attaches to the commutator bars, a spark will be drawn out every time this bar passes under a brush, and will generally cause a bright ring of fire to run around the commutator. If the trouble in this case is not located and remedied at once, the commutator will soon become badly burned.

***

(409) (*a*) In alternating-current lighting, can the secondaries of several transformers be connected together so that a transformer lightly loaded will help one that is overloaded? (*b*) If so, does it make any difference in what way they are connected? (*c*) Are both sides of a transformer considered of the same polarity?

F. L. N., Ashland, Ore.

ANS.—(*a*) The secondaries of two or more transformers may be connected in parallel so that the load will divide between them. When this is done, however, the transformers should be nearly alike in size and design. They should also be located near each other. If the transformers do not regulate alike, one is apt to take more than its share of the load, thus blowing its fuses and throwing all the load on the others. However, if care is exercised they may be made to work with their secondaries in parallel. (*b*) Yes; it makes considerable difference as to how they are connected. If you get the connections wrong you will have the secondaries in series instead of in parallel, and a dead short-circuit will result. Take the case where two transformers

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are to be connected in parallel; see that all lamps are disconnected from the secondary circuit. Connect up both sides of one of the secondaries to the circuit and one side of the other secondary; then connect the remaining terminal of the second transformer to the other side of the circuit through a piece of small fuse wire. If the wire blows, it shows that you have the two secondaries in series, and either one of the primaries or secondaries should be reversed. If the fuse does not blow, the connections are all right. (*c*) Neither pole of a transformer can, strictly speaking, be called positive or negative, because the polarity is continually changing. However, *at any given instant*, the two terminals will have opposite polarity, and it is this instantaneous polarity that has to be taken into account when connecting up transformers. If transformers are of the same style and make, those leads that are brought out of the case in the same way will usually have the same instantaneous polarity, though it is not always safe to assume this. The best way is to test out with a piece of fuse wire before connecting up permanently.

***

(410) Please tell me how to read the Weston ground detector? I have one that shows 40 degrees on both dynamo mains. The ground lamps do not show the ground the same as the instrument.

R. C., Annapolis, Md.

ANS.—The scale of the Weston ground detector usually reads directly in volts. When it indicates 40 it shows that the pressure across the terminals of the ground detector is 40 volts. The Weston ground detector is very much more sensitive than a lamp, and might indicate a ground that would be of too high a resistance to appreciably affect the lamps. It takes such a small amount of current to operate these ground detectors that a ground of quite high resistance would pass enough current to deflect the instrument 40 scale divisions.

***

(411) (*a*) How many batteries will it require to operate a telegraph line 120 miles long with 25 stations, each station having a relay and sounder? (*b*) In what part of the line should the batteries be placed? (*c*) How many cells should be used at each station for the sounders? The external conductor is galvanized-iron wire and the earth is used as a return circuit.

H. N. A., Kingston, Jamaica, B. W. I.

ANS.—(*a*) You have omitted two most important facts, namely, the size of iron wire and resistance of relays. We will assume, however, in order to show you how the number of cells may be calculated, that your line wire is No. 9 B. W. G., having a resistance of 15.5 ohms per mile, and that your relays have a resistance of 150 ohms each. These relays require .02 ampere, but on account of leakage losses, it is best to allow .08 ampere. There are 25 relays, hence the total relay resistance $= 25 \times 150 = 3{,}750$ ohms. The line resistance $= 120 \times 15.5 = 1{,}860$ ohms. If you use gravity cells, the electromotive force will be 1 volt, and the internal resistance 3 ohms per cell, if kept in good condition. The following formula gives the current: $C = \frac{s\,e}{s\,b + l + R}$, in which C = current; s = number of cells joined in series; e = electromotive force per cell; b = internal resistance per cell; l = resistance of the line; R = resistance of all the relays. By solving this for s, and substituting the values assumed above for the various quantities, we get $s = \frac{C(l+R)}{e - C\,b} = \frac{.08 \times (1{,}860 + 3{,}750)}{1 - .03 \times 3} = 185$ gravity cells. The values chosen above are those in common use. However, for a line as short as yours, with so many stations, you would get better results and require fewer cells by using 75-ohm, or even 50-ohm, relays. The conductivity of such a circuit would be so much better that the leakage losses, especially in wet weather, would not be near so troublesome. With 75-ohm relays, allowing them a current of .088 ampere, and with No. 8 B. W. G. wire, you would require only 144 gravity cells. (*b*) The 185 cells should be divided equally between the two end stations, that is, put 93 cells at one end and 92 at the other, being careful, of course, to get the two sets joined in the circuit in series, and not opposing each other. (*c*) You probably have 4-ohm sounders and they will require 2 gravity cells at each station, or 50 cells for the 25 stations.

***

(412) (*a*) What is the ratio of the resistance offered by a circuit using alternating current to the resistance of the same circuit using direct current? (*b*) In an alternating-current arc lamp, are both carbons consumed at the same rate? If so, why? (*c*) Explain the use of a two-rate meter, and also the diagram of circuits. (*d*) Does a recording wattmeter register with the series circuit open and the pressure coil connected to the line? (*e*) I have a ½ H. P. bipolar 10-ampere Crocker-Wheeler motor that I wish to change to 110 volts. Please give the necessary windings for the armatures and fields.

J. S. G., Galveston, Tex.

ANS.—(*a*) No definite values can be given for the ratio asked for, as it depends on the frequency, distance apart of the wires on the poles, power factor of the load, etc. By assuming approximate values for the above quantities, such as are liable to arise in practice, a table of values may be obtained that will answer for approximate calculations. We have not the space at our disposal to publish such a table, but you will find one in a small book entitled "Alternating-Current Wiring and Distribution," by Emmett, which may be obtained from The Technical Supply Co., Scranton, Pa. (*b*) Yes; the carbons burn at approximately the same rate, because the flow of current is continually reversing and is not always from the top to the bottom carbon, as in direct-current arcs. (*c*) A two-rate meter is an ordinary Thomson recording watt-hour meter provided with two dials and a clock that is kept wound by electrical energy supplied from the mains. Two small clutches are provided so that the clock may, at any hour for which it is set, throw one recording dial out of action and the other into action. In this way the meter during certain hours of the day records on one dial and during the remaining part of the time on the other dial. Hence two different rates may be charged, the power supplied during the daytime being supplied cheaper than that at night. As these meters are connected to the line in the same way as an ordinary Thomson meter, it is hardly necessary to give a diagram of connections. (*d*) No; not if the meter is properly made. (*e*) We cannot undertake to make such calculations. (See note at head of Answers to Inquiries columns.) Besides, in this case, the calculations could not be made without complete dimensions of the machine.

***

(413) I have an Edison dynamo that I wish to run in the opposite direction. Can it be done by simply changing the brushes, or must some other changes be made?

D. B., Muskegon, Mich.

ANS.—You have not stated whether the dynamo is shunt or compound wound. You must first reverse the brushes so that they will slant in the opposite direction from what they do at present. Then reverse the connections of the shunt terminals on the headboard of the dynamo. This is all that has to be done if the machine is plain shunt wound. If it has a compound winding, the terminals of the series coils must also be reversed. By changing the field connections in this way the machine will generate

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when run in the opposite direction, and the polarity of the field magnets will be the same as before the change was made. Since, however, the direction of rotation is reversed, the polarity of the brushes will be opposite to what it was before the change.

BUILDING TRADES

(414) Where can I procure a book giving rules for figuring and information concerning lumber and log measurements and lumber grading?

W. B. S., Hermanville, Mich.

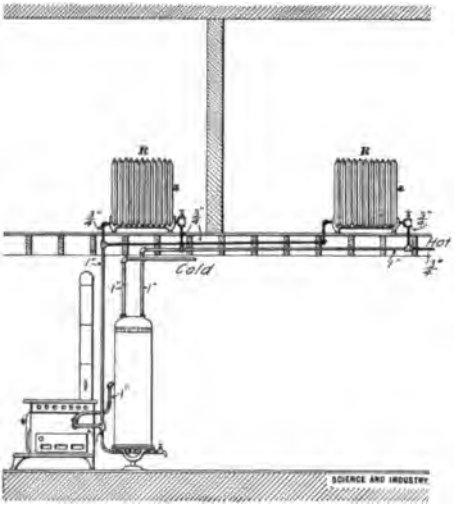
ANS.—The "Lumberman's Handbook," by W. B. Judson; illustrated, contains 202 pages, giving all the information that you could possibly require. Price, cloth, $1.25. This work can be procured from The Technical Supply Co., Scranton, Pa.

***

(415) (*a*) Is it practicable to heat two small rooms directly over the kitchen with hot water from the range boiler in the kitchen? (*b*) How are the pipes connected between the boiler and the radiators?

R. M. A., Lancaster, Pa.

ANS.—(*a*) If your waterback is large enough and if you fire the kitchen range sufficiently during extremely cold weather to give you the proper amount



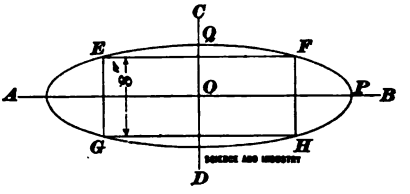
of heat in the rooms, it will be quite practicable to connect radiators to your kitchen boiler. Otherwise, you will not get good results. (*b*) The accompanying illustration shows the way the connections may be made so that the circulation to the radiators will be independent of the water-supply system, and will not affect the distribution of hot water through the building, whether the radiators are in operation or not. The arrangement shown favors the distribution of hot water to the plumbing fixtures rather than circulation to the radiators in the room, it being supposed that the heating of the rooms over the kitchen is a matter that will come next to the requirements of hot water for plumbing purposes. The circulation to the right-hand radiator can be increased by dropping the return pipe down into the kitchen before connecting it to the other return pipe. We would advise you to do this if you conveniently can. There is a little liability, in the arrangement shown, for the left-hand radiator to short-circuit the right-hand radiator. The 1″ pipe shown is used to counteract this.

***

(416) The sum of the two radii of an ellipse is 20 in. The axes of the ellipse are AB and CD. The lines EG and FH are drawn perpendicular to AB, so that $EG = FH = 8$ in. Find the length of the equal lines EF and GH, and also the two radii.

O. F. N., Beloit, Wis.

ANS.—The data are insufficient to determine the radii of the ellipse, for there are an indefinite number of ellipses satisfying all the given conditions.



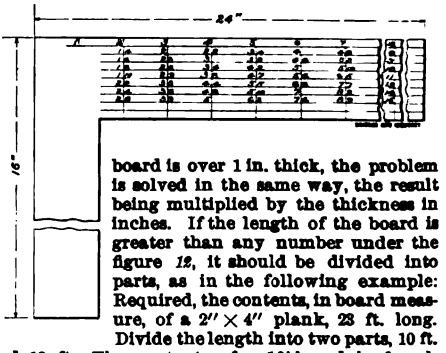
Let a denote the length of the radius OP; then the length of the radius OQ is $20 - a$; and the length of EF is $\frac{2(20-a)\sqrt{a^2-16}}{a}$. We can give a any value greater than 10 and obtain the corresponding lengths of OP, OQ, and EF. For example, making $a = 15$, we have $OP = 15$ in., $OQ = 5$ in., and $EF = 9.64$ in., nearly.

***

(417) I have a 2-foot steel square with figures on both sides. The figures on one side are the same as in the accompanying sketch. I do not understand them. Will you please explain their meaning?

J. B., New York, N. Y.

ANS.—The markings on the plate you show are given to facilitate the figuring of the number of board feet in lumber, and can best be explained by an example. Let it be required to find the number of board feet in a 1″ × 5″ board, 13 ft. long. Under the 12″ mark, find the number *13*, and follow the horizontal space in which *13* is found, to the 5″ mark. The answer is then found to be $5\frac{1}{12}$ ft. B. M. If the



board is over 1 in. thick, the problem is solved in the same way, the result being multiplied by the thickness in inches. If the length of the board is greater than any number under the figure *12*, it should be divided into parts, as in the following example: Required, the contents, in board measure, of a 2″ × 4″ plank, 23 ft. long. Divide the length into two parts, 10 ft. and 13 ft. The contents of a 10′ board is found, as before shown, to be $3\frac{4}{12}$ ft. B. M. That of the 13′ board is $4\frac{4}{12}$ ft. B. M. Therefore, the total contents (if 1 in. thick) is $3\frac{4}{12} + 4\frac{4}{12} = 7\frac{8}{12}$ ft. B. M., and as the board is 2 in. thick, the contents is twice $7\frac{8}{12}$, or $15\frac{4}{12}$ ft. B. M.

***

(418) (*a*) What should be the size of the pieces composing a wooden lattice girder as per accompanying sketch, Fig. 1? How should it be constructed? The total load to be supported by the

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girder is 51,300 lb. There are no intermediate supports. (*b*) Give calculations, etc., for this girder. (*c*) What size brick piers should be provided at the girder ends, the piers to be laid in good cement mortar?

G. N. O., New York City.

ANS.—(*a*) Several important items have been omitted. For instance, you have failed to state of what kind of timber the truss is to be built, and also what depth it should be. We have assumed that the truss is to be constructed of yellow pine, preferably Georgia yellow pine, and that it is to be 5′ 6″ in depth. The size of the members and details of construction, allowing a factor of safety of about 4, will then be as designated in Fig. 2. The chords of the truss are composed of three pieces of timber 4″ × 12″ in section. (*b*) The calculations are too lengthy for consideration in the inquiry columns. We would, however, refer you for methods of calculating the stresses in the members to an article entitled, "Mechanics of Carpentry," appearing in the November, 1899, and the March, 1900, issue of SCIENCE AND INDUSTRY. This article deals with the Howe truss, and in figuring the stresses in the lattice girder it is necessary to omit the counters. By *counters*, we mean the diagonal members extending from the bottom chord upward to the left, Fig. 2. These counters are only necessary under a moving load, but as they add great stiffness to the truss, even under a statical load, it would be well to use them. Omitting these members, you will notice that the structural features of the truss are the same as in the one with which the article deals. Having the stresses, you can readily calculate the dimensions of the members from the usual tables giving the tensile strength of iron and the compressive and shearing strength of wood. We would recommend in all such calculations that you use "The Building Trades Pocketbook," which can be obtained from The Technical Supply Co., Scranton, Pa., for $1.50. (*c*) Considering that the piers are laid in good Portland cement mortar and built of hard-burned brick, the dimensions in Fig. 2 will be adequate, provided the height of the pier is not over 20 ft.

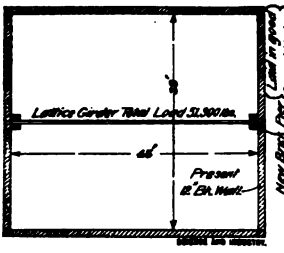

FIG. 1

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(419) (*a*) I have a drying room that is to be heated by the hot-blast system, the air being drawn over and through steam coils by means of a fan and discharged through galvanized-iron piping into the room. Owing to the tendency of my material to crack, it is desirable to maintain moisture in this room at 60% or 65% daily. With less than this percentage, I find that my material will crack, and, of course, if the moisture runs very much above this, I lose much in the time of drying. Is it possible for me to put in an automatic arrangement for controlling the percentage in this dry room? I recirculate the air from the room, which usually contains a large amount of moisture, but at times, as the material becomes dry, the moisture is insufficient to keep up the above percentage. (*b*) Can you also give me a formula for figuring the percentage of moisture in air, using the dry and wet bulbs, as I find tables giving this percentage go only as high as 100°, and I should like to figure this percentage as high as 200° or 250°. I also have a steam pipe with small holes in it, between the heater and fan, from which I can blow steam into the air chamber, allowing the air to become saturated, but this method, of course, requires the constant care of one man to control it.

C. E. C., Yonkers, N. Y.

ANS.—(*a*) We do not know of any arrangement for automatically controlling the humidity of the air in your drying room. If any of our experienced readers know of such a contrivance, we will be pleased to hear from them. (*b*) We might give you a formula to compute the humidity of your drying room at high temperatures, but we consider it more beneficial to you if you purchase a "Huddleston Hygrophant" from B. F. Sturtevant Co., Boston, Mass. This instrument is especially designed for high temperatures, and appears to be just what you require. Full instructions will be sent with the hygrophant.

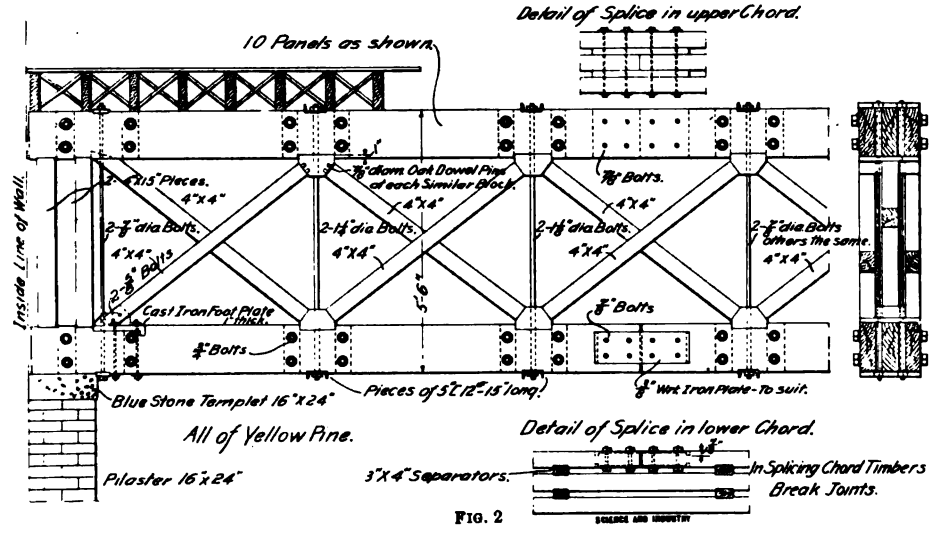

FIG. 2

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(420) (*a*) Explain the method of figuring the size of beam required to support the tank shown in the accompanying sketch, Fig. 1. (*b*) Are templets required under the ends of the beams?

G. M. O'R., New York.

ANS.—(*a*) First figure the bending moment in inch-pounds on the beam, which is obtained for a single concentrated load at any location from the formula $M = \frac{x\,y\,w}{l}$. In this formula, M = bending moment in inch-pounds; x = distance in inches the load is located from one support of the beam; y = distance in inches the load is located from the other support of the beam; w = load on beam in pounds; l = span of beam in inches. Having the bending moment, or M, on the beam, it is necessary to determine the resisting moment, or M_1, of the beam section; because, in order that any beam shall be sufficiently strong to sustain its load, the equation $M = M_1$ must be true. This resisting moment $M_1 = QS$, Q being the section modulus of the beam section and S the safe unit fiber stress of the material. The value of Q, or the section modulus of a rolled-steel I beam can best be found from the tables, usually headed "Properties of Rolled-Steel Sections," which are to be found in the handbooks published by the various steel mills throughout the country, or in "The Building Trades Pocketbook" (see advertisement in this magazine). If such tables are not handy, this value Q for an I beam can be approximated, though not closely, by the formula $Q = \frac{A\,d}{3.2}$. Here A = area of the beam section in square inches; d = depth of beam in inches. Since often only the weight and depth of the beam are known, the sectional area of the beam can always be ascertained by dividing the weight per foot of the beam by 3.39. The safe unit fiber stress, or S, for structural steel in buildings, is usually considered at 15,000. From the above information, the calculation of the beam required in the

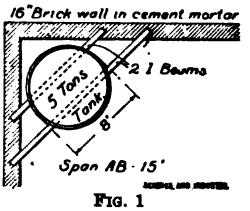


FIG. 1

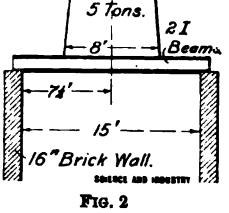


FIG. 2

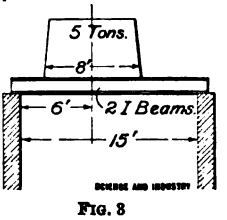


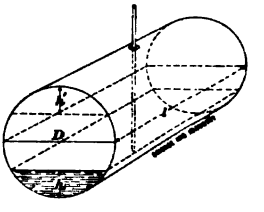
FIG. 3

arrangement as shown in Fig. 2 can be made as follows: The load on the outside beam equals 2½ tons, or 5,000 lb. Hence, $M = \frac{x\,y\,w}{l} = \frac{90 \times 90 \times 5{,}000}{180} =$ 225,000 in.-lb. Since $M = M_1$, and $M_1 = QS$, 225,000 must equal QS. As S is known to be 15,000, Q must equal 225,000 ÷ 15,000 = 15, which is the section modulus required in the longer beam. In order to avoid excessive deflection, the depth of an I beam in inches should usually never be less than one-half its span in feet. In this case, a beam 8 in. in depth and weighing 22 lb. per ft. will be assumed. The area of this beam is 6.4 sq. in., and from the formula $Q = \frac{A\,d}{3.2}$, the section modulus is found to equal $\frac{6.4 \times 8}{3.2} = 16$. This beam, as will be observed, is somewhat in excess of the strength required, but it is close enough to be economical. The same size of beam can be used in the arrangement shown in Fig. 3. (*b*) It would be better to use bluestone templets, say 8 in. wide × 12 in. long × 6 in. thick, though if the wall is laid in good cement mortar they are hardly necessary.

MISCELLANEOUS

(421) I frequently have occasion to measure black oil in iron drums that have bung holes in the side of the drum. I want to make a measure similar to a yardstick, so that when it is let down into the drum and withdrawn the indication marks on the measuring rod will show the quantity of oil in gallons in the drum. The drums are round and measure about 8 in. in diameter and are 4½ in. long. Please give a rule for finding the quantity of oil in the drums at different heights. H. A. P., Mt. Pleasant, Tex.

ANS.—It is not clear to us whether the drums rest on their sides or ends; but we assume the former to be the case. Let D be the diameter of tank; l, its length; and h, the depth of liquid in it. Then, to find the number of gallons for each inch in depth, multiply the cross-sectional area, in square inches, of the liquid (the shaded portion in diagram) by the length in inches, and divide the product by 231. The cross-sectional area a may be found by the following closely approximate formula: $a = \frac{4\,h^2}{3}\sqrt{\frac{D}{h} - .608}$.



Assume h = 1 in., 2 in., 3 in., etc., and find the corresponding values of a in square inches. Multiply each value of a by l in inches, and divide by 231. Each result will be the number of gallons for the given depth of liquid. If the depth is greater than half the diameter of the tank, the height h and its corresponding area should be found, and the latter result *deducted* from the area of the circular end, before multiplying by l, etc. Having found the capacity corresponding to each inch in depth, mark it on the rod, or make a table.

* * *

(422) (*a*) How can I convert small scraps of platinum to a platinic-chloride solution used in photography for toning? (*b*) How can I recover the gold from old gold-chloride toning baths?

W. R. J., Rossland, B. C.

ANS.—(*a*) The scraps of platinum to be reduced must first be cleansed thoroughly and cleared of all impurities by boiling in a dilute solution of nitric acid. They should then be rinsed thoroughly in warm water and dissolved in aqua regia. This consists of a mixture of from 2 to 4 parts nitric acid and 1 part of muriatic or hydrochloric acid and is the only solution that will dissolve gold and platinum. When the scraps are thoroughly dissolved in this, the solution should be boiled down and finally slowly evaporated over a water bath. A most convenient way of doing this is to place the solution of platinum scraps in a Florence flask and suspend the latter in a beaker of water under which an alcohol

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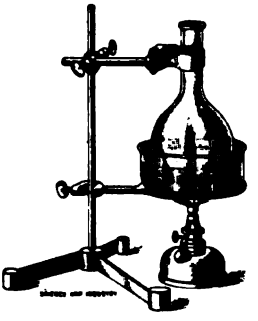
lamp burns, as shown in the illustration. While the solution is slowly evaporating, small quantities of hydrochloric acid should be added from time to time, and then the whole allowed to evaporate to dryness. The residue will be platinic chloride. (*b*) The reduction of metallic gold from old toning baths is a much simpler process, and may be accomplished by pouring into the gold solution a saturated



solution of sulphate of iron, which will precipitate the gold in a metallic form, and it may then be recovered by pouring the solution through filter paper and drying the residue. If the gold bath is muddy, it should be filtered before the sulphate of iron is added, in order to remove all foreign matter. Having thus precipitated the metallic gold from the solution, it may be dissolved in aqua regia and treated in the same manner as the platinum, to reduce it to gold chloride. Owing to the nicety required in performing these chemical operations, it will usually be found more economical to sell the gold and platinum scraps to a jeweler and invest the proceeds in the ready prepared salts.

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(423) (*a*) Where R = radius of gyration of an entire section of the form shown in the accompanying sketch, r = radius of gyration of a single angle about an axis through its center of gravity, and d = the half width of column minus the distance from outside of angle to neutral axis of same, can the formula $R = \sqrt{r^2 + d^2}$ be applied to a square column of any size having any size of angles with equal legs? (*b*) Please give the derivation of the formula.

E. B. T., St. Augustine, Fla.

ANS.—(*a*) Yes. (*b*) This formula depends on the principle that *the moment of inertia of a plane section about an axis not through its center of gravity is equal to its moment of inertia about a parallel axis through its center of gravity plus the product obtained by multiplying the area of the section by the square of the distance between the two axes.* Let A denote the sectional area of any one of the four equal angles; let I denote its moment of inertia about the axis through its center of gravity (neutral axis); let I' denote its moment of inertia about the parallel axis through the center of gravity of the entire section; and let d denote the distance between these two axes. For a symmetrical section, d has a value as stated above. The principle just stated enables us to write for each angle section the equation $I' = I + A d^2$, and as $I = A r^2$, this can be written $I' = A r^2 + A d^2$. This being the same for each angle, we can write for the entire section, $4 I' = 4 A r^2 + 4 A d^2$. As $4 I' = 4 A R^2$, we have the equation $4 A R^2 = 4 A r^2 + 4 A d^2$, from which $R = \sqrt{r^2 + d^2}$.

***

(424) What is the best smoke-consuming device to be applied to boilers using soft coal?

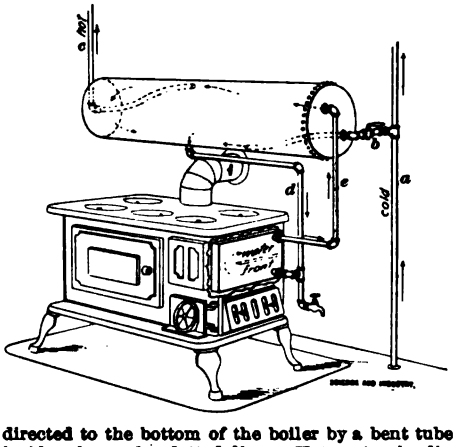
W. F. G., Springfield, Mass.

ANS.—Under the conditions existing in the furnace of a boiler, smoke once formed cannot be consumed. From this you can judge yourself of the merits of a device sold as a "smoke consumer." It is entirely feasible to so construct a furnace that the formation of black smoke will be prevented to a large extent. There are quite a number of patented furnace constructions that, when intelligently handled, will give quite satisfactory results. Obviously, we cannot recommend one of these to the exclusion of the others. Many engineers believe that skilful firing will accomplish more than any special furnace construction. We expect to publish an article on smoke prevention in the near future.

***

(425) I wish to place a kitchen-range boiler in a horizontal position about 1½ ft. higher than the range. Will it work as well this way as in the usual upright position? E. C. D., Cherryfield, Me.

ANS.—It will work satisfactorily if you connect it up right. Boilers are made especially for horizontal connections, but an ordinary upright boiler can be turned over and connected in a horizontal position just as well. The accompanying illustration shows how it may be done. The service pipe from the street is shown at *a*; a branch is taken off to supply cold water to the boiler, a stop-cock being placed on it at *b*. Cold water flows through this branch and is



directed to the bottom of the boiler by a bent tube inside, shown by dotted lines. Hot water is distributed to the fixtures by the pipe *c*, a bent tube being used inside the boiler to draw the water from the top. If this tube is not put in the upper part, the boiler will become filled with compressed air instead of hot water. The pipe *d* connects the side tapping of the boiler to the lowest tapping in the water front, or water heater, a sediment cock being placed in the lowest point to drain the apparatus when necessary. The pipe *e* connects the highest opening of the water front to the highest opening in the head of the boiler. The arrows show the direction of the circulation of the water. The boiler supports are not shown; these will depend on the character of the surroundings and existing conditions. It is customary to rest the boiler on brackets bolted to the top of the range.

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(426) A square piece of paper cut as in Fig. 1 has an area 1 sq. in. greater when the pieces are arranged as in Fig. 2.; why is this?

L. A. Bridgeport, Conn.

ANS.—It is really painful to receive a question of this kind, since any one can satisfy himself of its falsity by attempting to fit the pieces together as required, or by attempting to draw Fig. 2 from the dimensions given in Fig. 1. The latter is the better way, and, if the drawing is made full size, the gap shown in Fig. 2 along the diagonal ab will be so large as to convince any one that the pieces will not fit as shown. That the area of the opening is 1 sq. in. may be calculated in a number of ways, one of which is as follows: The figure $adbc$ is a parallelogram, ad being parallel to cb and ac parallel to db; hence, its area $= db \times ce$, ce being perpendicular to db. To find ce, we must know the angle ebc, which equals the difference between the sum of the angles dbf and cbg and 90°. Tan $dbf = 3 + 8 = .375$; hence, $dbf = 20° 33' 21.7656''$. Tan $cbg = 5 + 2 = 2.5$; hence, $cbg = 68° 11' 54.9296''$. Angle ebc $90° - (20° 33' 21.7656'' + 68° 11' 54.9296'') = 1° 14' 43.3048''$. Length of $cb = \sqrt{2^2 + 5^2} = 5.385165$. Consequently, $ce = cb \times \sin 1° 14'$

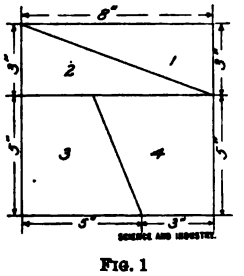

FIG. 1

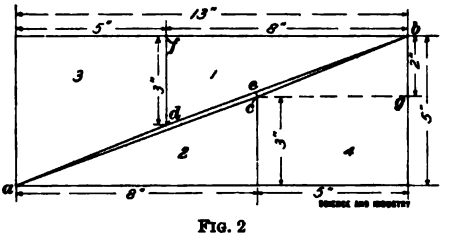

FIG. 2

$43.3048'' = 5.385165 \times .02178396 = .1170410$. Since $db = \sqrt{3^2 + 8^2} = 8.544004$, area of parallelogram $= 8.544004 \times .1170410 = .9999968$ sq. in., or 1 sq. in., correct to 6 figures.

***

(427) Where can I get a book on the splicing and handling of ropes? W. E. Q., Scranton, Pa.

ANS.—The Technical Supply Co., Wyoming Avenue, Scranton, Pa., can furnish "Knots, Splices, Hitches, Bends, and Lashings," by F. R. Brainard; price $1.

***

(428) How is the sin, cos, tan, and cotan of any angle, say 56° 43' 17", found by the use of logarithms?

O. O. D., Massena, N. Y.

ANS.—The functions of an angle—sin, cos, etc.—cannot be found directly from a table of logarithms; they are given in tables having much the same form as tables of logarithms. These tables give the values of the different functions for each degree, and usually for each minute. The values for seconds must usually be obtained by a system of interpolation. For convenience in calculations in which logarithms are used, tables giving the logarithms of the functions have been prepared. The tables giving the functions themselves are called "tables of natural functions"; those giving the logarithms are called "tables of logarithmic functions."

***

(429) A certain king ordered his jeweler to make him a crown of gold weighing 68 oz.; the jeweler attempted fraud by substituting a portion of silver, but the king suspecting fraud, requested Archimedes to examine the crown. Putting it into water, he found that it displaced 8.2245 cu. in. of water, and, having found that an inch of gold weighs 10.36 oz., and an inch of silver 5.85 oz., Archimedes discovered the part of the king's gold that had been stolen. Report the process and give the result.

A. C., Barnett's Creek, Ky.

ANS.—The process that Archimedes followed is not known, and the accounts of this incident that have come down to us vary much. The problem as stated above is solved at the present time in the following manner: Volume of the crown = 8.2245 cu. in.; therefore the weight per cu. in. of the alloy used in the crown = 68 + 8.2245 = 7.66 oz., nearly. The excess of weight of a cu. in. of gold over the weight of a cu. in. of alloy = 10.36 — 7.66 = 2.7 oz., and the excess of weight of a cu. in of alloy over the weight of a cu. in. of silver = 7.66 — 5.85 = 1.81 oz. Then, by alligation, a mixture of 2.7 parts of silver and 1.81 parts of gold will weigh the same per cu. in. as the alloy used in the crown. That is, out of every 4.51 (= 2.7 + 1.81) parts, 2.7 parts are to be silver and 1.81 parts are to be gold. Therefore, $\frac{2.7}{4.51}$ of 8.2245 = number of cu. in. of silver used in the crown, = 4.9288; and $\frac{1.81}{4.51}$ of 8.2245 = number of cu. in. of gold used = 3.3007. Had the crown been made of gold, it would have had a volume of 6.0611 (= 68 + 10.36) cu. in. The gold stolen was 6.0611 — 3.3008 = 2.7802 cu. in., which is nearly 46 per cent. of the gold that was to have been put in the crown. The student will understand the above problem much better if he will read the article entitled "Rule for Mixtures" in HOME STUDY MAGAZINE, for March, 1898.

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(430) (*a*) About what are the wages of a practical mechanical draftsman? (*b*) Is there a union or association of mechanical draftsmen? If so, please give address of secretary. (*c*) Is there a paper of any kind published in the interest of mechanical draftsmen? J. M., Ridgeville, Ill.

ANS.—(*a*) We do not know just what you mean by the term "practical" as applied to mechanical draftsmen. The pay of draftsmen ranges from $40 to $50 per month for men who depend mostly on others for the general plans and calculations pertaining to the work being done. For men who can design new work, the pay runs up to $2,000 per year and more. (*b*) We do not know of any. An attempt to form such an association was made some time ago, but we do not know that it was successful. (*c*) There is no paper devoted especially to the interests of draftsmen. Nearly all mechanical and engineering papers however, have articles from time to time dealing with subjects in which they are interested.

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SCIENCE AND INDUSTRY

Vol. V OCTOBER, 1900 No. 9

PUBLIC SUPPLIES OF ENERGY

Alton D. Adams

A COMPARISON OF STEAM, GAS, AND ELECTRICITY AS SOURCES OF ENERGY FOR LIGHT, HEAT, AND POWER

THE public demands light, heat, and power. These demands are met largely by the development of energy in apparatus on the premises of consumers, but partly by distribution from public plants and stations. Originally, all necessary energy was generated at the points of use. General supply systems have now displaced isolated equipments to some extent, through the offer of cheaper or more satisfactory service. Of the total amount of light, heat, and power consumed in centers of population, it may safely be said that only a small percentage is as yet derived from public plants. The larger part of the energy now drawn from general distribution systems is used for lighting, a smaller portion for mechanical work, and a comparatively unimportant amount for heating purposes. On the other hand, the actual consumption of energy for heating and power is far in excess of that necessary for illumination. The latent energy of gas must be developed as heat on the consumer's premises before its application to illumination or mechanical work.

The first step in the production of electric energy at central stations is the combustion of fuel in the boiler furnace. At first it seems curious that heat, the form of energy that must necessarily be produced in the development of light or power from fuel, and that of which the largest quantity is required, should be least important in systems of distribution. A little consideration, however, is sufficient to discover the reasons for these conditions. In the first place, heat, being directly produced by the combustion of cheap fuels, is generated on the consumer's premises at a comparatively small expense. If light is wanted, either a fuel much more costly than coal or wood must be employed, or recourse had to the public supply of gas or electricity. Another factor that favors the distribution of energy for illumination is the superiority of gas or electric light over candles and oil lamps. The private individual can develop heat at two to four times its cost per unit at central stations, but in the production of light of the best quality he is at a much greater disadvantage. Consumers are therefore prepared to pay a rate for energy used in illumination that they will not pay for heating energy. Gas and electricity are very convenient for heating purposes, but the former can attain only a moderate and the latter a minute success for general warming. Aside from the heavy fixed expenses and labor charges incident to the supply of gas and electricity from public plants, the low efficiency of such systems is sufficient to prohibit their general use for heating purposes. Coal is the source of energy to which as a usual thing both the private consumer and the central station must ultimately resort. So long, therefore, as public plants are able to deliver to their patrons a decidedly smaller part of the energy of coal than may readily be obtained from isolated equipments, the general distribution of heat is at a disadvantage. Distribution systems that supply only a small part of the energy of coal, whatever its use, must evidently obtain a comparatively high price per unit sold. An increase in the percentage of fuel energy that central stations are able to supply to consumers should consequently tend to reduce the rate for the entire output. On the other hand, if a public plant, that already distributes a very large part of the fuel energy at a certain rate per unit, is in a position to supply a part of its output

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in a different form, which commands a much higher price, it is an obvious advantage to do so.

The bearing of these considerations on present practice is to be found by an examination of several methods of energy distribution. Public plants now commonly distribute energy in three ways: by steam, gas, and electricity. Central steam plants for general heating, if equipped with the best class of boilers, may deliver 75 per cent. of the fuel energy to the distribution pipes. Allowing a moderate loss by radiation and conduction, 65 per cent. of the heating power of coal is available at the consumer's premises. Gas plants differ as to their kind, in the ratio between the energy of the gas produced and that of the coal consumed. Coal gas proper, or that derived from soft coal by distillation in closed retorts, contains 25 per cent. of the energy of its coal. There are other products of the distillation, however, that are of considerable value. Pure water gas, or that derived entirely from hard coal or coke, retains 40 per cent. of the heating power of these fuels, but they are entirely consumed in the process. Coal gas in many cases, and water gas in almost all cases, is enriched by the use of petroleum, but this treatment can change in only a slight degree the efficiency of the product as to coal. Electricity is less effective than either steam or gas, as to the portion of fuel energy that it can be made to transmit. The lack of efficiency is not inherent in the electric system, but in the steam equipment that must be used to drive it. Allowing boiler plant, engines, electric generators, and circuits to have efficiencies of 80, 15, 90, and 95 per cent., respectively, which is more than they will average in the best class of stations, the consumer can receive about 10 per cent. of the fuel energy. The efficiency of central-station supply thus varies from approximately 65 per cent. for steam to 40 per cent. for gas and 10 per cent. for electric energy, taking the heating power of coal as a basis. Each of these forms of distribution exists because of its special fitness for certain purposes, and neither alone can hope to supply the greater part of the required energy at any center of population.

Heating stations are operated in a number of cities for the sole purpose of steam distribution. By the great majority of consumers steam can be used only for heating purposes, as machinery is necessary to make possible the production of light as well as of power. The public demand for steam is very much greater as to general warming than for cooking and industrial operations, consequently a very large part of the capacity of a central heating plant must remain idle during one-half of the year. The limited period during which public heating stations can earn a satisfactory return on their large investments, and the fact that their form of energy is the one most easily generated by consumers, constitute a serious check to the extension of such plants.

Gas is available for both heat and light without the intervention of machinery, and consequently has a much wider field of application than central-station systems of steam heating. At the rates commonly charged for each, gas is somewhat cheaper for illuminating purposes than electric energy, and it must continue to be largely so used unless the rates for electricity are materially reduced. Gas is already extensively used for cooking and for heating in industrial operations, and also to a small extent for general warming. So long as rates at all like the present are charged for gas, however, it will be unable to seriously compete either with distributed steam or house fires for general warming.

Electric energy, representing only 10 per cent. of the heating power of fuel, obviously has a poor start in the competition for public heating, and the large element of fixed charges included in its cost per unit is a further disadvantage. As long as electrical machinery depends on the steam engine for motive power, there is no probability that electric heat can find any extended application for general warming.

How little adapted to the heating of buildings are gas and electricity at current rates may be seen by a comparison with coal as to cost. At five dollars per ton for hard coal, one dollar pays for 400 pounds. On perfect combustion such coal may fairly be assumed to yield 13,000 heat units per pound, so that the total possible heat from the 400 pounds is 5,200,000 units. Taking the lowest common rate for gas, that is, one dollar per 1,000 cubic feet, and the average heating power of illuminating gas at 650 units per cubic foot, the heat that may be obtained for one dollar is 650,000 units, if the gas is perfectly burned. A low general price for electric energy is 10 cents per kilowatt hour, or 1,000 watt-hours for one dollar. The heat equivalent of 10,000 watt-hours is 34,120 units of heat. Comparing

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these figures for maximum heating effects, it appears that one dollar invested in coal at five dollars per ton yields eight times the heat that may be had from a like purchase of gas at one dollar per thousand cubic feet, and more than one hundred and fifty times the electric equivalent of heat that may be secured for one dollar, at the rate of 10 cents per kilowatt hour.

The possible heating power of coal, gas, and electric energy, as just given, is not an exact index to their relative practical values. All of the heat that may be generated by the perfect combustion of coal can never be usefully applied, but a part must always be lost. The best boilers absorb about 80 per cent. of the total heat energy of coal, while ordinary boilers and stoves, such as are used in many business blocks and residences, do not have an efficiency of more than 50 per cent. Gas can usually be burned with more nearly perfect combustion than coal, and electric heaters for general warming have an efficiency of 100 per cent. Making due allowance for these different advantages in application, gas and electricity still remain much too expensive for purposes of general heating. So far, public supplies of gas and electricity seem suited only to the distribution of light and motive power. Central steam-heating plants are able to supply consumers with a large percentage of fuel energy at a rate much below that for an equivalent service with gas or electricity, but still too high to encourage great extensions of such plants. It has thus grown common for residences and mercantile buildings to be lighted from central stations, while they are heated in the great majority of cases with local stoves or heaters. In a large and growing class of buildings, however, light, heat, and power are all generated on the premises, and it is from such cases that an important lesson may be drawn for central stations. An isolated steam and electric plant of moderate capacity, with equipment of decidedly lower efficiency than that used at central stations, will supply light and power in a building cheaper than it can be had from gas or electric service, and heat at a lower rate than the public heating system.

The isolated plant burns two or three times the coal per horsepower hour that is consumed in the central station, but during nearly one-half of each year the exhaust of engines at the isolated plant goes into the heating system. Exhaust steam at the central station may be used in a condenser, but even then the condensing water carries away 70 to 80 per cent. of the heat that the steam brought from the boiler. The isolated plant, through the variety of service it renders, keeps most of its machinery in use during nearly all of the year. The central steam-heating station is, to a large extent, idle in the summer and must make up during the winter for a large fixed annual expense. When the central electric station and the public heating plant are united, the total efficiency of operation will be raised, the proportion of fixed expenses reduced, and the general supply of light, heat, and power extended.

HEATING WATER WITH STEAM COILS

STEAM coils submerged in tanks are frequently used for heating water for large buildings. Exhaust steam from engines is generally used for this purpose, and a live steam connection is made by which live steam can be turned on in case the engines are shut down. The amount of coil heating surface used in large tanks is about 1 square foot for every 15 gallons of capacity of the tank; or, what is the same thing, 1 lineal foot of 1-inch pipe for every 5 gallons in the tank. The capacity of a large hot-water storage tank best adapted for general use is found in practice to be about as follows:

Families to Be Supplied.	Gallons per Family the Tank Should Hold.	Total Capacity of Tank in Gallons.
10 to 15	22 to 25	250
15 to 20	20 to 22	330
20 to 25	18 to 20	400
25 to 30	16 to 18	450

The above table is constructed on the assumption that the families do no laundry work. If laundry work is included, the tanks should be made at least 50 per cent. larger on account of the enormous demand on washing days.

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MACHINE-SHOP MEASUREMENTS

By a Machinist

APPROXIMATE AND PRECISE MEASUREMENTS DEFINED—THE ERRORS OF MEASUREMENT. REDUCING CUMULATIVE ERRORS BY PROPER METHODS OF MEASUREMENT

THE measurements made in machine shops may, in general, be broadly divided into two classes: measurements of approximation and measurements of precision. The difference between the two classes is one of degree rather than of kind; in the true sense of the word, all measurements that can be made are only approximate, no matter what refined methods are used. Absolutely correct measurements, i. e., those that do not vary at all from the nominal size, distance, or angle, are only the result of accident; we cannot conceive of any means that will tell us when a measurement agrees exactly with its nominal value. Custom, however, has drawn the dividing line between the two classes of measurement at a certain limit of variation from the true size. While there exists a difference of opinion about where one class ends and the other begins, it is believed that the most general practice is to classify as measurements of precision those that do not vary more than $\frac{1}{1000}$ inch from the true size. In scientific work, the limit of variation within which work can be finished depends only on the refinements of measurement adopted and the skill and ingenuity of the person performing the work; in commercial work, the limit of accuracy is usually clearly defined by the money the customer is willing to pay for the work.

The adoption of one or the other class of measurement depends on the accuracy required. In most cases, both classes are used on a job, since work is rarely of such shape as to require measurements of precision for each and every part of it.

Approximate measurements are those made with the aid of an ordinary graduated steel scale and a caliper, dividers, scribing block, surface gauge, etc. While an expert, using the greatest care and working with a magnifying glass, can set calipers by a steel scale within a limit of variation of $\frac{1}{1000}$ inch of the true size, there are comparatively few people who can do so. Generally speaking, the limit of variation may be placed at $\frac{2}{1000}$ inch; it requires quite close work to attain even this accuracy.

Precise measurements depend primarily on gauges of various kinds representing commercially accurate subdivisions of the standard yard. These gauges, among which may be mentioned the standard end-measure pieces made by Pratt & Whitney and the reference disks made by Brown & Sharpe, are carefully ground and lapped to a size not varying more than $\frac{1}{10000}$ inch from the true size. Gauges of this degree of accuracy are naturally quite expensive, and are not intended for use in the machine shop, but rather for the testing of micrometers, vernier calipers, and similar shop measuring instruments. The precise measurements the machinist, as a general rule, is called on to make, depend for their preciseness on his sense of touch; these are measurements of contact. As a matter of course, it is here assumed that the measuring instrument used—a micrometer, for instance—is commercially correct.

With an accurate instrument and a finely developed sense of touch a surprising degree of accuracy can be obtained by direct contact measurement; instances are numerous where machinists have finished work that, on being tested by more refined methods, was shown to be accurate within $\frac{1}{10000}$ inch. Very little work the machinist is called on to do will need such exactness, however. To get within a limit of variation of $\frac{1}{10000}$ inch is possible for almost any one. It may sound like a very small amount, but its magnitude will be realized very forcibly when a hardened, ground, and lapped plug is placed between the anvils of a micrometer set just to touch the plug. The difference in the force required to push the plug through the opening when the micrometer is screwed up $\frac{1}{10000}$ inch will prove a surprise to any one who has never felt this demonstration of the magnitude of the ten thousandth part of an inch. While granting that an expert may get better results, generally speaking the limit of accuracy of ordinary contact measurements may be placed at that figure. It must not be inferred, however, that all work can be or is done within this limit of variation; while it is possible to attain this accuracy for *one* contact measurement, it is unreasonable to expect to get it when a

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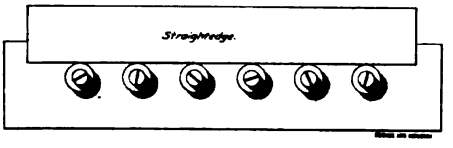
number of successive contact measurements have to be made in order to obtain a precise over-all dimension. The total error will probably be more than the error in any individual measurement.

The accompanying illustration will make this clear. The problem given is one that frequently arises in one form or another. In this case six holes are to be bored in some part of a jig; the holes are required to



be in a straight line, equidistant, and 1 inch apart. They are to be bored with the greatest possible degree of accuracy attainable with the measuring instrument at hand, which is a one-inch micrometer. Under the circumstances, some machinists would locate the centers of the holes by temporarily attaching small annular circular steel disks of known diameter to the work by fillister-headed screws and placing them the required distance apart by the aid of a temporary gauge filed up to a length equal to the center distance of two adjacent holes diminished by the sum of the radii of the two adjacent disks. If all disks are alike, the same temporary gauge will answer for each division. The disks are placed in line by being brought up against a true straightedge. The work is then placed on the face plate of the lathe and trued up until one disk runs true; the disk is then removed and the hole bored. This operation is repeated until all the holes have been made. Now, while each hole may have been originally located within, say, $\frac{1}{10000}$ inch, the errors of measurement may have accumulated until the center-to-center distance between the end holes may vary an amount considerably in excess of the limit of variation of a single contact measurement. In a job of the kind here shown, the errors that prevent absolute accuracy are as follows:

1. The error of the measuring instrument. This, with an instrument purchased from a reliable maker, is usually exceedingly small.

2. Error in measuring the size of the disks. This should not exceed $\frac{1}{10000}$ inch.

3. Error in making the temporary gauge. This need not be more than the previous error.

4. Error in placing the disks equidistant and at the required distance. Its magnitude will be a combination of errors 2, 3, and 4. These errors may accumulate or neutralize, partially or entirely.

5. Error in chucking the disk to run true. This need not exceed $\frac{1}{10000}$ inch, if a sensitive indicator is used.

6. Error in boring. Its magnitude depends upon the skill of the workman; it may be infinitesimal or quite appreciable.

On examining these errors and knowing that some of them cannot be obviated entirely, it is seen that the best that can be done is to reduce each one to the lowest possible limit. The better the sense of touch is trained, and the more skill used, the more accurate will be the final result.

We will now investigate the elimination of errors for this particular case. If a two-inch micrometer is at the disposal of a toolmaker, error 3 can be eliminated entirely, since the micrometer can be used directly over any two adjacent disks. Error 4 will also be reduced, since there is one measurement less to be made for the location of any two adjacent disks; that is, there are now three contact measurements instead of four. Error 2 can be diminished, if the disks are exactly alike, by placing three or four on a flat surface plate, pushing them all in contact with a straightedge and each other, and then measuring their combined size, and finally dividing the measurement by the number of disks. Error 1 cannot be eliminated by any means at the command of the toolmaker; errors 5 and 6 can be minimized by careful work.

From the preceding discussion it is seen that it is advisable, in order to secure accuracy, to make a careful study of the way in which the measurements can be made. In general, it may be stated that where a number of successive contact measurements are necessary, they should be reduced to the smallest number feasible with the instruments at hand; when they are needed for intermediate parts and the object sought is accuracy of the combined length of these intermediate parts in addition to their own accurate location, make first of all the longest measurement circumstances permit, and from it obtain the subdivisions. This applies to approximate measurements as well. For the purpose of making this clear, let us assume, in the job shown in the illustration, that the distance between the end holes is required to be as precise as it can be made. Then, facilities permitting, the two disks locating them should be adjusted first

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of all, and the intermediate disks from these in turn.

It may be laid down as a general rule that where several methods of measurement are feasible, the method that involves the fewest and most direct measurements should always be chosen. On reflection it will be seen that no rules can be given for the different methods of measurement. The workman must consider the means at hand and the nature of the job; he must then use his ingenuity and be guided by his practical experience.

For measurements that have to be made within a smaller limit of variation than is attainable by direct contact measurements, special forms of instruments based upon the principle of the micrometer are used. In these machines special devices show the degree of contact of the measuring surfaces with the work. They are to be found in a few of the leading shops where accurate work is done, and are intended for measurements within a limit of variation of $\frac{1}{10000}$ inch. They are rarely used for work other than the making of standard gauges intended for the testing of the ordinary measuring instruments.

GAS LEAKS

Gas Fitter

PRECAUTIONS TO BE OBSERVED IN CASE OF AN ACCUMULATION OF GAS—WHERE LEAKS ARE LIKELY TO BE FOUND

GAS LEAKS, as generally looked on by the public, are simply trifling inconveniences that create a disagreeable odor that can be tolerated for a long time before headache results. But the headache does come, and often worse troubles, too, if gas leaks are not promptly remedied. The effect of a gas leak, or the consequences, if you please, will depend considerably on the magnitude of the leak and the manner in which people are compelled to pay attention to it.

Suppose you go to bed leaving a peep of gas burning, just for convenience in case the baby should cry during the night, and a gust of wind should somehow blow out this light. You sleep on in blissful ignorance, but awake next morning with an aching head or perhaps sick at the stomach. These are effects of inhaling gas in small quantities.

A farmer who has been accustomed to blowing out his oil lamp the last thing every night before he tumbles in to rest his weary bones, forgets himself in the city hotel where he is "putting up" temporarily, carefully makes his room door and windows burglar-proof, then blows out the gas and slips in between the sheets with the feeling that after all there is "no place like home." About 2 or 3 o'clock in the morning the night watchman discovers a strong smell of gas in the vicinity of this room. After vain efforts to arouse the occupant, the door is finally forced, only to find that the poor fellow has been partially or entirely asphyxiated. An ambulance and physicians or undertakers do the rest. This is the result of inhaling a large amount of coal gas.

But another danger from gas leakage, and one, too, that is quite important, is that fire may reach the accumulation of gas and cause an explosion. Undoubtedly, more human lives have been lost through gas explosions than through asphyxiation. An explosion occurred on one of the busiest streets of Scranton, Pa., but a few days ago. Two brick buildings of the genuine American box pattern, apparently as substantial as any other building of their class, were totally demolished in the twinkling of an eye. The accompanying illustration shows the wreckage a few minutes after the dust had cleared away. There were nine persons in these buildings at the time of the explosion. Willing hands soon released the imprisoned ones from the wreckage, and to the great joy of the thousands of spectators, it was found that no one was killed; even the baby that was cuddled up close to its mother's bosom was found to be uninjured. In addition to the occupants of these houses who were injured, many people on the street were severely hurt by flying glass.

The exact cause of this explosion is much debated by the public. Some people who have handled explosives for years say that the wreckage resembles the work of dynamite, while others who are familiar with the effects of gas explosions in mines declare that the explosion was undoubtedly due to

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gas. It is asserted to be a fact, however, that gas filled the building to the right in the illustration, the first floor of which was occupied by a bank, and that the watchman, after banking hours, descended the cellar steps to shut off the gas cock at the meter. He had scarcely reached the cellar floor when he observed that a gas jet burning in the rear had ignited the gas and that a wave of blue flame was rolling along the cellar ceiling toward the front. Being an old miner and accustomed to gas in mines, his good judgment told him to lie down close to the corner, which he instantly did, just as the gas exploded, when the entire building fell on top of him. Presence of mind probably saved his life.

Just where the gas came from is, of course, unknown, but it is believed to have escaped either from a gas pipe that had been fused by an electric wire or from leaks under the street. It is a well known fact that gas escaping from a street main will ooze up through the ground if the street is not paved, but if the surface of the street is impervious, the escaping gas will find its way into sewers and cellars. As the street in front of this wreck is paved with asphaltum, and as gas leaks are frequently caused by slight settlements of the ground, such as have occurred to this street on several occasions, it is rational to suppose that this gas came in through the cellar wall. In any case, it was there and became ignited.

In cases of this kind, or whenever there is reason to suppose there might be an accumulation of gas, every precaution should be taken to prevent an explosion. As soon as an odor of gas is detected in any building, the gas fitter should be called in at once. If the smell is strong, all doors and windows should be opened wide to let out the gas as quickly as possible, and some one who knows where the stop-cocks are located should go and shut off the gas; but under no consideration should he take a light along. If possible, this should be done without drawing a breath. If it is necessary to breathe in such a place, the nose should be placed near the floor, for the gas is usually found near the ceiling. If there is a liability of his being overcome, he should keep in communication with another person who can rush in and pull him out should he cease to answer inquiries.

Gas alone will not explode when a light is applied; to be explosive it must be mixed with air to a certain extent, which varies slightly with the kind and quality of the gas. One cubic foot of illuminating gas of ordinary quality requires to be mixed with a quantity of air varying from 5½ to 13½ cubic feet before an explosion will take place; between these limits explosion will occur,

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but the most intense explosion takes place when the proportion is 1 of gas to about 9½ of air. When there is less than 5½ cubic feet of air to 1 cubic foot of gas, the mixture will burn but not explode.

When an explosion takes place the gaseous mixture is instantly increased to about three times its original volume. If the gas is confined in a chamber so that it cannot expand, the pressure instantly increases to about 30 pounds per square inch by the gauge. In the case of the wrecked building shown in the illustration, there was an increase in pressure that raised the heavy sidewalk, raised the floors of the building, blew out the lower part of the front wall and a large hole in the rear wall, and knocked the first-story party wall into the adjoining wrecked building; the force of gravity did the rest.

To aid the householder in locating gas leaks, and thus help him to prevent disasters of the kind illustrated, let us consider the most common forms of leaks and the places in which they are most likely to be found. If the gas pipes are made of wrought iron, have been tested and proved gas-tight, and have been in use for some time before an odor of gas is noticed, the leak, if in the building, will probably be found at the gas fixtures or at the meter. The small stop-cocks on the fixtures often work loose and gas escapes around the keys. If a key is loose in its socket it is very liable to be opened accidentally or to be reopened unintentionally in the act of removing the fingers after closing it. A loose key is such a dangerous thing that it should not be permitted to remain loose under any circumstances.

If the odor of gas is stronger in the cellar than in the living rooms, the leak will probably be found at the meter couplings. These, as a rule, are only leather or rubber, which rot and cause leakage. Sometimes the couplings themselves have worked loose, or it may be found that the meter leaks. In any case, if the odor does not subside after the gas is shut off at the meter, it is well to notify the gas company in writing and keep a copy of the notice, for you may want to sue them for damages for neglect.

SENSITIVE THOMSON GALVANOMETER

R. M. Wilson

DETAILS OF CONSTRUCTION OF A GALVANOMETER THAT IS EASY TO MANAGE AND OF EXTREME SENSITIVENESS—ITS PROMINENT ADVANTAGES

THE following description and drawings are of a galvanometer designed by Prof. W. S. Franklin to meet the requirements of the Department of Physics of Lehigh University. The instrument is inexpensive and at the same time extremely sensitive, but peculiarly easy to handle. It consists of a base and two frames of well-seasoned cherry supporting four small coils that act on an astatic needle suspended by a silk fiber, and the deflections of the needle are read by a mirror either with a lamp and scale or a telescope and scale, as desired.

The coils each contain about 2½ ounces of No. 36 B. & S. double silk-covered copper wire, a total of about 10 ounces for an instrument. The coils are wound upon a metal form (see Fig. 1), so arranged that it can be easily held in the chuck of a lathe. It is not necessary to keep the layers distinct; rough-wound coils are quite as satisfactory. After the coil is wound, the form with the coil on it is allowed to soak in melted beeswax and resin, half and half, for 10 or 15 minutes. It is best to place the vessel with melted mixture and coil under the receiver of an air pump, to insure extracting all of the air from the coil; however, this is not absolutely necessary. The coil and form are next cooled (with water, if desired, as the whole is now entirely waterproof) and the front plate of the form removed after heating it slightly with a warm iron. The form itself is now heated slowly and the coil removed, when free, by a slight twist. The coils thus made will be found to be firm and readily handled without danger of breaking. Fig. 2 shows the shape of the coils when removed from the form.

The base of the instrument is 1 in. × 7½ in. × 7½ in., and to it is both glued and screwed a corner block 2 in. × 2 in. × 3 in., of cherry. The front and rear blocks for coils are each 1 in. × 3 in. × 9 in. These blocks are very much alike, as will be seen from Fig. 3; they are of the same size, both

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have sawn grooves to receive glass strips, both have openings for coils, and both have ⅛-inch diameter holes *f* to give access to the rear of the binding screws. The rear block is glued and screwed to the corner block (see holes *e* countersunk for No. 12 flat-headed 1½-inch screws). At the top and bottom of the rear block is attached ⅛-inch spacing blocks of wood or hard rubber; the top spacing block is cut away to give plenty of room for the needle and its suspension fiber. Through the front block is a hole 1 inch in diameter, opposite the mirror. The holes *c* are drilled for No. 12 round-headed 1¼-inch brass screws which serve to clamp the front and rear blocks together, these screws fastening in the holes *d* in the rear block.

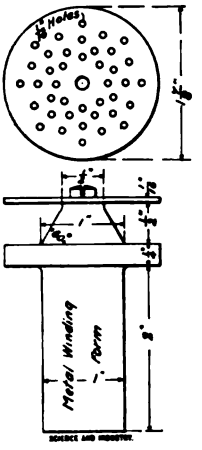

FIG. 1

On the front and rear of the instrument are two hard-rubber pieces ⅛ inch thick, pieces are drilled holes *j* on the axes of the coils, and the front piece has the hole *h* opposite the mirror. This hole must be covered by a window (preferably of thin glass, but mica will do) sealed to the front board. If a lamp and scale is to be used with the galvanometer a spectacle lens may be let into the front board. This lens should have a focal length of one-half the distance from the mirror to the scale desired. On top of the blocks for the coils is a brass plate (Fig. 4) attached to the rear block only by two No. 8 round-headed ¾-inch brass screws at *g*. To this plate is soldered a brass tube ⅜ inch outside diameter and 4 inches long. The top of this tube is slitted and receives a brass plug to which the suspension fiber is attached.

FIG. 2

To properly mount the coils in the blocks, proceed as follows: Upon a piece of white paper draw two ⅝-inch circles, 2 inches between centers; place over this a piece of

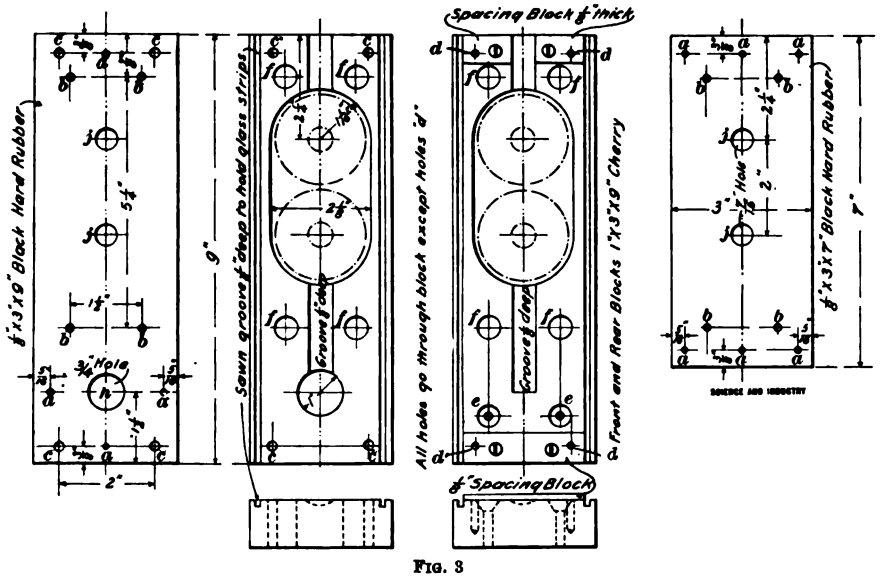
Spacing Block ⅛" thick
⅛"x3"x9" Block Hard Rubber
Sawn groove ⅛" deep to hold glass strips
All holes go through block except holes d
2 Front and Rear Blocks 1"x3"x9" Cherry
⅛"x3"x7" Block Hard Rubber
⅛" Spacing Block
SCIENCE AND INDUSTRY

FIG. 3

3 in. × 9 in. and 3 in. × 7 in., respectively. These are attached to the blocks by No. 4 round-headed ½-inch brass screws *a* (Fig. 3). To these hard-rubber pieces are attached the binding posts at holes *b*, which are drilled to suit the posts. Through both window glass 3 in. × 6 in. or larger, and on the glass place one of the blocks, grooved side (inner side) downward and adjust so that the circles are directly below the location of the centers of the coils. When adjusted, clamp all together with a pair of

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carpenter clamps. Next place the coils in position with the large end of the hole upward, and adjust by looking at the circle through the hole in the coil. Around the

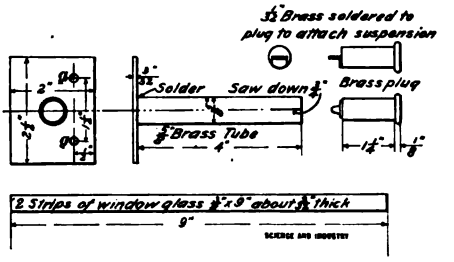
½" Brass soldered to plug to attach suspension
Solder
Saw down ¼"
Brass plug
Brass Tube
2 Strips of window glass ½" x 9" about ⅛" thick
9"

FIG. 4

coils pour a melted resin and beeswax mixture with a spoon until the space is filled, then take two 1½-inch diameter circles of thin clear mica and seal them over the openings through the coils. When cool turn the coil and glass over, and on the glass lay a second glass and then the other block, adjusting the blocks so that their corners exactly coincide, and clamp them together. Place the coils for the second block exactly opposite those of the first block and seal them in as before explained. When cool the blocks can be removed from the glasses by warming the glass slightly.

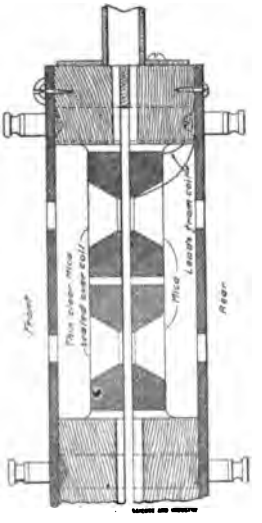

FIG. 5

Fig. 5 is a section of the instrument showing the coils mounted in place.

The blocks can now be finished by putting on the hard-rubber fronts, spacing blocks, binding screws, etc., and then the complete instrument can be put together. The glass strips shown in Fig. 4 can then be slipped into the grooves between the blocks, to keep the air from disturbing the needle.

The needle consists of a glass fiber .02 inch or .03 inch in diameter and 6 inches long, having a small light mirror attached at one end and two groups of small magnets so located that when the mirror is opposite the large hole in the front block the groups will come exactly central with the coils.

To make the magnets, take a piece of No. 8 music wire .019 inch in diameter, straighten it and cut it into convenient lengths. Heat these red hot in a piece of tin bent into a trough, as shown in Fig. 6, and quench with water to harden them. The wire may now readily be broken into ¼-inch lengths by placing it on a pine board and pressing with a sharp edge at the point where the break is desired. Next, cut two pieces of very thin mica ¼ inch square and stick the magnets on them by means of shellac. Take a piece of small glass rod and heat it in a flame until soft, and then, removing it from the flame, quickly draw it out into a fine glass fiber. When drawing, one hand should be vertically over the other, and as soon as the rod is pulled as far as desired release the tension immediately, otherwise the fiber will not be straight. Select a portion of the fiber about 6 inches long and determine whether it is straight by rolling it between the fingers.

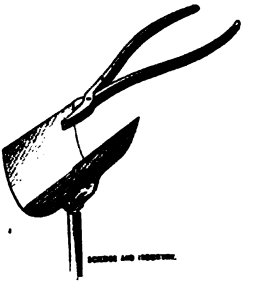

FIG. 6

The mirror should be made of microscope *cover* glass. The mirror *must* be light, so its size had better be confined to ¼ inch square or $\frac{5}{16}$ inch round. If the mirror is heavy, the needle, when started, will vibrate a long time before coming to rest, i. e., will *not* be "dead-beat."

To mount the mirror and magnets upon the glass fiber, mark out the positions of each (see Fig. 7) accurately on a piece of paper and place the mirror and magnets face downward in their positions, daubing shellac on their backs; lastly, lay the glass fiber in place and allow the shellac to dry. The magnets can now be magnetized in the directions shown in Fig. 7, by placing them between the poles of an electromagnet.

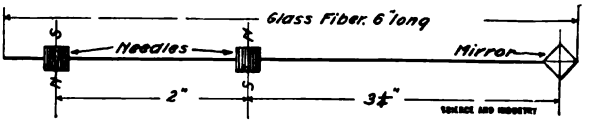

FIG. 7

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The suspension fiber is obtained from a piece of white floss silk, the silk being unraveled until a single fiber can be withdrawn. The fiber is attached by shellac to the glass fiber and the brass end plug. When the shellac is dry the end plug with the needle suspended is carefully lifted and the needle lowered through the brass tube until the magnets are on the axis of the coils, that is, opposite the holes *j*. The length of the silk fiber should be such that the end plugs will now extend about ¼ inch into the brass tube. The galvanometer should be leveled up so that the needle swings free and is central with respect to the coils. This adjustment is readily obtained for the windows *j* and the side strips of glass permit the needle and fiber to be seen for the greater part of their length. The completed instrument is shown in Fig. 8.

The coils can be connected up properly by trial, either in series or parallel, as desired, thus: Apply a small E. M. F. to *one* coil and note the deflection; then connect another coil into the circuit, and if the deflection is *less*, the coils are opposed and the terminals of one of them should be reversed, and so on, adding the third and fourth coils to the circuit. It does not necessarily follow that two coils will give twice the deflection of one unless the current in each of the two coils is the same value as in the one.

Inasmuch as the instrument is not air-tight, drafts may disturb the needle, and if so a small box having a window opposite the mirror can be inverted over the galvanometer.

The following are some of the more important features of this type of instrument:

1. It is inexpensive and easily constructed.

2. It is extremely sensitive, indicating currents as small as $\frac{1}{10000000000}$ ampere.

3. It is quite dead-beat if supplied with a light mirror.

4. The windows and the glass side strips facilitate adjustment and inspection.

5. The needle and fiber can be readily removed for inspection or repairs and as readily replaced.

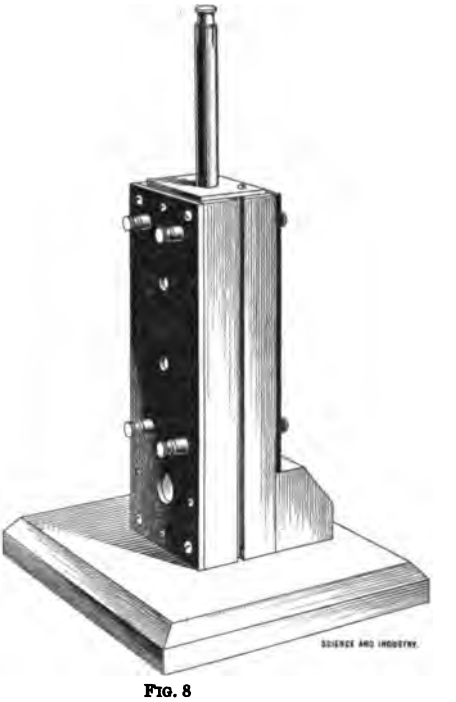

FIG. 8

6. The instrument can be easily opened; the screws at *c* being removed, the front block is entirely free.

RAILWAY MILEAGE

ON June 30, 1899, the total single-track railway mileage in the United States was 189,294.66 miles, an increase during the year of 2,898.34 miles being shown. This increase is greater than for any other year since 1893. The states and territories which show an increase in mileage in excess of 100 miles are Alabama, Arkansas, Georgia, Louisiana, Michigan, Minnesota, Pennsylvania, Texas, Arizona, New Mexico, and Oklahoma. Practically all of the railway mileage of the country is covered by reports made to the Interstate Commerce Commission, the amount not covered being 0.93 per cent. of the total single-track mileage. The aggregate length of railway mileage, including tracks of all kinds, was 252,364.48 miles. The distribution of this aggregate mileage was as follows: Single track, 189,294.66 miles; second track, 11,546.54 miles; third track, 1,047.37 miles; fourth track, 790.27 miles; yard track and sidings, 49,685.64 miles.

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A NEW ERA IN AMERICAN SHIPS

Geo. E. Walsh

INCREASE IN CARRYING CAPACITY AND REDUCTION IN SPEED—OCEAN GREYHOUNDS NOT PROFITABLE—SHIPS IN COURSE OF CONSTRUCTION

AMERICAN ship building has passed through many discouraging periods of evolution, and the height of its remarkable development in the middle half of the present century can hardly be measured by the period of stagnation that has fallen upon it for the past two decades. Of this latter, we have had enough, and no fruits of our war in Cuba and the Orient are better appreciated as a whole than the new interests that have been stimulated in ship-building circles. A part of the present activity in the shipping interest is due to the general prosperity of the country and to the withdrawal of some ships from the paths of commerce for war purposes; but, after due allowances are made for these, the fact remains that the American ship-building industry is entering upon a new era that may carry it to the high-water mark of half a century ago. Abundant and indubitable facts point toward the promising future of American ship building of war vessels, ocean steamers, yachts, and coasting vessels.

There are certain tendencies in this new movement that show the changes in the commercial needs of the country. The day of the small vessel has nearly passed, and those from 4,000 tons up are the universal favorites. A vessel of this size can be handled with the same number of men as required for one of half the tonnage, and its earning capacity is thereby materially increased. Hand in hand with the growth of larger vessels of enormous carrying capacity will go the reduction in speed. The fast vessels, which are built primarily to carry passengers and the mails, and incidentally to break records, are not profitable investments. They do not pay, whether flying under the American or British flag, unless heavily subsidized. There is sentiment in the thought of owning these handsome greyhounds of the ocean, but they are costly luxuries and their number will be limited. On the Pacific, where trade with the Orient is to develop, the new vessels will all be of large size and immense carrying capacity, and of comparatively slow speed. It is promised that over twenty-five of these large steamers will be engaged in the Oriental trade with our Pacific coast within the next five years. Every shipyard on the Atlantic and Pacific today is busy, and it is impossible to place new contracts for a vessel anywhere in this country. Within the next six months a large fleet of ocean steamers, coasters, wooden ships, and war ships, will be launched.

This is not a matter of guesswork or of prophecy, but is an actual fact, based on the returns of the different ship-building plants and the investigations of the Commissioner of Navigation. Our own new navy furnishes considerable work for the plants, and the agitation for keeping one ship in the process of construction in each of the important navy yards all the time is likely to meet with a favorable outcome. There are fifty war vessels, of an aggregate displacement of 140,813 tons, in the course of construction or under contract in the various seacoast shipyards, and, besides these, Congress has authorized six other war ships, of 76,500 tons displacement, the contracts for which have not yet been let. These war vessels run all the way from the small torpedo boats up to the magnificent battle ships of the Kentucky and Kearsarge type. The growing needs of our navy tend to stimulate competition in the construction of vessels of every type, for, after the ship-building plant is once thoroughly equipped, it can accept orders for widely different types of vessels.

It may be said that our new navy consequently gave the first incentive to the present movement in American ship building and induced builders to equip large and expensive plants at favorable points along the two coasts. Otherwise the present demand for American ships could not have been met in even a partially successful way. On the Pacific coast, the large steamers in the course of construction represent an immense tonnage in the aggregate. For the Hawaiian trade alone there are four steamers on the stocks with an aggregate gross tonnage of 26,500. The Pacific Mail Steamship Company has two large steamers partly finished, and The International Navigation Company has two more, while the Oceanic Steamship Company (Spreckels) have three

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building. On the Atlantic coast there are three large steamers in the yards for the Cuban trade. These ten steamers represent over 81,000 gross tons, and they do not include the new coasting traders.

There are over forty-five vessels of the latter class in course of construction or under contract in this country, and as their gross total tonnage is over 76,000, their average size must be decidedly larger than the average coaster built in former days. In this list are included some small vessels of not much more than local importance, and their small size increases the average capacity for the larger number of big ships. The large four- and five-masted sailing vessels are in great demand, and one at least is being built of 5,500 tons and with six masts.

The rates for ocean freight are higher by 25 per cent. today than they were a year ago, and the cost of construction has advanced proportionately because of the higher cost of lumber and structural iron and steel. These two offsetting factors do not seem to influence the course of the trade to any appreciable extent, and, from present indications, we may look for new fleets of American ships on the water by next summer, while others will take their places on the stocks of a score of different Atlantic and Pacific shipyards. Those who have the interest and glory of the American flag on the high seas at heart will find these harbingers for a new era of American ship building good reasons for being satisfied at the course of history in the past two years.

THE STORY OF AN UNSTABLE FOUNDATION

M. M. Sloan

How a Test of the Soil Might Have Prevented Damage to Property and Avoided Great Expense

TROUBLE and expense often might be avoided by testing the bearing qualities of foundation soils, and although such a precaution should not be neglected, especially when there is suspicion of unreliable strata, it is one that is seldom taken in the erection of a two- or three-story residence. It was with considerable interest that the passers-by watched the erection of a handsome home on one of the residence streets of an inland city. To say that the house was well built would hardly convey an idea of the excellence of the workmanship and the material employed. From the copper cresting and finials of the roof to the finely chiseled Indiana limestone trimmings and neatly turned balusters, all betokened the amplitude of the owner's purse and the care and taste of the architect. How imposing it looked in all the glory of its yellow-brick front and renaissance woodwork, proudly rearing its wide dormers and tall chimneys among its neighbors of the more humble sheathing and shingle types, like a colonial production masquerading in the finery of modern materials.

"The Arch of the First Story and the Brickwork Above Succumbed, Together With the Heavy Stone Sill of the Second Story"

On many an evening the observer, as he wended his way homeward, has seen the owner, sometimes alone and at other times with the architect, watching with satisfaction the progress made each day—a satisfaction that almost amounted to ostentatious pride when the roof line and chimney cap became outlined against the western evening sky. Sometimes they would stay until the moon shed its silvery light over the classic details, and then, if one were to listen, the architect might be

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"THEN, FOLLOWING THE LINE OF LEAST RESISTANCE, THE UNSIGHTLY BREAK NEXT APPEARED AT THE CORNER OF THE SECOND-STORY WINDOW HEAD AND CONTINUED UPWARD TO THE PLATE"

heard to say, as he passed from one vantage point to another,

"If thou wouldst view fair Melrose aright,
Go visit it in the pale moonlight."

Such was the state of affairs that existed above the level of the street. But alas! the high hopes of the owner were checked and the reputation of the architect somewhat dimmed by the unseen and unsuspected agencies that were assiduously and subtly at work below the surface, directly under the north side wall and the outlying pilasters that added their attractiveness to the principal façades of the building.

The house stood on the slope of a hill and faced the summit; parallel with the top of the soil, but some eight or ten feet beneath, lay a stratum of hard rocky shale, over which, in rainy weather, a stream of water from the drainage of a considerable area worked its way. Some distance below the house this stream disappeared into a hole or fissure in the hard stratum and was lost in some mysterious underground canal, carrying with it, as time wore on, the under surface of the soil.

The erection of this unfortunate building was begun directly over this channel, and the excavation for the foundation presented a seemingly fair and solid bearing stratum. But appearances are sometimes deceitful, and the supposedly secure foundation proved to be nothing but an arch of earth, which, while able to support its own weight, refused to carry the load of brick, stone, and timber that the architect saw fit to impose. So, one evening, after the noise of the hammer and saw had ceased, and the owner had come and gone after bestowing a fond look on his palatial residence, now nearing completion, the arch, tired of supporting the weight that was constantly being augmented, slowly but somewhat rudely deposited its burden on the underlying hard stratum. It was in vain that the heavy stone footings and foundation walls, and the close-laid brickwork in cement mortar endeavored to resist the effects of having its support drop from under. As such materials were never adapted for cantilevers, they failed, in this instance, to have the strength of such a structural member, and a wide break appeared in the foundation walls and then extended to the heavy water table. The arch of the first story and the brickwork above succumbed, together with the heavy stone sill of the second story. Then, following the line of least resistance, the unsightly break next appeared at the corner of the second-story window head and continued upward to the plate.

The building stood thus for several weeks, an object lesson to all who beheld it, and an exemplification of the old saying that experience is a dear teacher but an exceedingly good one. What shall be done? was the

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question that probably worried the architect more than it did the owner. What was necessary to be done in order to remedy the fault can better be shown than described. The days passed until, after fourteen or more had drifted into the oblivion that is known as the irrecoverable yesterday, finally one morning the sounds of returning activity that could be heard bore testimony to the fact that some scheme of procedure had been decided on and that the architect had not donned his thinking cap in vain.

From the manner in which the workmen commenced on the handsome pile, it looked for a while as though the entire building was to be torn down. One thing certain was that the owner had decided that what was worth doing at all was worth doing well. The chimney came down first, and was followed by the demolition of the side wall, together with a portion of the front and the supporting foundation, until, as shown in the illustration, the house presented an excellent opportunity for the study of modern building construction in sectional elevation. It was quite evident, from the number of steel rails and cement barrels and the quantity of broken stone delivered on the ground, that a grillage foundation was to be built over the soil that had proved so treacherous and caused disaster to the building. The rails were laid lengthwise and crossed with others somewhat shorter, and the whole was imbedded in concrete well tamped. It was in this manner that the irresponsible arch of earth was overlaid by the firm composite lintel of concrete and steel that was to support on its widespread area a new foundation wall of brick instead of the rubble that had been used before. The wall was relaid, and the stone sill, chimney moldings, and pilaster carefully reset, so that no vestige of the accident was left. The structure thus stands supported at one end by a spread footing on a wide area and the remainder of the building on the foundation of rubble masonry, as first constructed.

"THE CHIMNEY CAME DOWN FIRST, AND WAS FOLLOWED BY THE DEMOLITION OF THE SIDE WALL, TOGETHER WITH A PORTION OF THE FRONT"

This arrangement will prove satisfactory unless excessive settlement takes place, in which case the new footings will not settle uniformly with the rest of the building, and its pleasing façade may yet be defaced by those inevitable signs of structural weakness, cracked brickwork, disjointed arch, and broken sill.

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CONDENSATION IN STEAM PIPES

Chas. J. Mason

PROVISIONS FOR TAKING CARE OF CONDENSATION—BY-PASS VALVES AND THEIR USES

CONDENSATION of the steam in steam pipes takes place owing to the radiation of heat from the pipes; even when the pipes are well covered this occurs to a certain extent, and some disposition must be made of the water before it has a chance to enter the engine cylinders.

In small plants where the engine is not remote from the boiler, the condensation usually returns to the boiler, which is made possible by giving the pipe a "drop" toward the boiler; the water will naturally flow to the lowest point, which is the boiler itself. Should the engine be on the same level as the boiler, or even lower, necessitating a vertical drop pipe from a certain point in the horizontal steam pipe, then the point from which the vertical drops should be the highest in the horizontal line; this will cause the water of condensation to flow to the boiler instead of to the engine. There should also be a drain pipe at the base of the vertical pipe, so that when about to start the engine the pipe may be cleared of water before the throttle valve is opened. This drain pipe usually leads to the sewer or some other outlet for the water, because, owing to this pipe being used only in starting the engine, it is not usually considered important enough to be connected with the feed system, as is the case with some other drain pipes in use in large plants.

In some cases, particularly where high-speed engines are in use, there is a separator between the engine stop-valve and the base of the vertical drop pipe. This appliance, as the name implies, separates the water of condensation from the steam before it passes into the cylinder, and it also intercepts any slugs of solid water that may "lift" from the boiler and be carried along with the steam in the pipe. In course of time this separator would become filled with water if no provision were made to constantly drain all water that it contained. This is accomplished by running a pipe of suitable size from the base of the water side of the separator to an apparatus called a "trap." There are many different makes of traps on the market, but they all accomplish the same purpose—that of draining off the water and at the same time preventing the escape of steam. The mechanism of the trap is so arranged that the contained water opens the outlet and drains off until the following steam fills the trap and closes the outlet, thus imprisoning the steam until it in turn condenses and is ready to be disposed of. Then this filling and emptying of the trap, with its consequent opening and closing of the outlet, is alternately carried on as long as steam is in the pipe to which the trap is connected. The condensation thus collected in the trap usually empties into a receiver that has a pump attached; this pump, in turn, is automatically actuated and controlled by the quantity of water in the receiver. When the water rises to a certain height in the receiver, a float within that is connected externally by levers and rods to the throttle valve of the pump, opens the valve and starts the pump that delivers the water into the feed system of the boilers. As the water is gradually lowered in the receiver, the float follows and closes the throttle, stopping the pump until a new supply of water again starts it.

In case of stoppage occurring through the failure of any of the parts to work properly, or if it is necessary to temporarily stop the pump to make repairs, or pack the rods, etc., the condensation from the trap may be by-passed into the sewer through a valve and connection for that purpose. Traps and receivers are used where the engine is not sufficiently high to admit of the water flowing back to the boilers by gravity.

In summing up the foregoing, the following brief statement may be made: Where possible, condensation from steam pipes should be returned to the boiler by force of gravity; this is the most economical method, because no mechanism is required for the operation other than the pipes through which it flows and the check valve to prevent its return. Not only is the gravity system desirable on account of its economical feature, but also because of its simplicity and the certainty of action. Where the gravity system may not be used, the trap, receiver, and pump are installed to deliver the water of condensation to the feed system of the boilers. In both systems there should be, as before mentioned, a by-pass to the sewer

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or some other such place, to be used in case of the derangement of any of the parts, or in case it is desired to entirely drain the main pipe, after it has been cut out of service to allow repairs to be made. It may be well to explain, for the benefit of the non-technical reader, that the expression "cut out of service," just used, is not meant in its literal sense—that of actually cutting out or disconnecting the pipe; but it is to be taken in the sense that it is, for the time being, shut off from the boilers.

In regard to the design of the main steam pipe for plants, it may be said that two general systems are in use: the overhead, and that where the pipes are led under the floor and up to the engine at the point of connection. Each of these systems has its advantages, and the use of either is governed largely by the local conditions and surroundings.

In the overhead system, in a plant having a large and long main pipe from which the condensation is drawn off through several pipes at stated distances along the entire line, the water of condensation may be returned to the boilers by the force of gravity without the assistance of the steam loop. This is, of course, a decided advantage, but it is considered unsightly to have a network of steam pipes exposed to view in the engine room, and not only that, but valuable space, which in some instances can be ill afforded, is thus occupied. In large plants where the various parts of the engine are handled by an overhead traveling crane while under repairs, the overhead system of piping seriously interferes with the operation of the crane and in some instances entirely excludes its use for certain parts.

In the second system referred to the condensation is trapped to a receiver and delivered to the feed system as previously explained. Under certain conditions it may be returned by gravity through the medium of the loop, but even in that case it is advisable to also have the receiver and pump as a secondary means to fall back on. In the below-floor system a separator would not be required on the engine cylinder, for in this case the top instead of the base of the upright pipe is connected to the engine stop-valve, and consequently the water will gravitate to the bottom.

In large plants with many units it is preferable to install the below-floor system where conditions fully permit of so doing; but in ordinary and small plants it is seldom or never done, because the conditions rarely warrant it, and in some instances it would be entirely unprofitable to install such a system.

Aside from the selection of one of the two systems above mentioned for a prospective plant, the actual design of the piping will depend on the relative positions of the boilers and engines, and also on the number of each of them. No hard-and-fast rules can be laid down for an installation, and usually this is left to the judgment of the designer. There are a few things, however, that should be observed in the design of piping, and they are applicable to either system, independent of the relative positions of the boilers and engines or of the symmetry of the plant.

The allowance for expansion and subsequent contraction must be considered in the design. As to which method of taking care of the expansion is to be adopted, depends largely on the choice of the designer and also on the general layout of the plant. In some instances the expansion will be taken care of by the many changes in the direction of the pipe, made necessary by the location of the engines, without having recourse to special methods. The condensation and the method by which it is to be disposed of must also be considered with a view of attaining the best results.

Piping should be as straight and direct as possible, with the exception of the part that admits of expansion, for the greater the number of turns and bends the more restricted will be the flow of steam through the pipe. There should be a gradual reduction in the size of a main steam pipe toward the end farthest from the boiler, to allow for the reduced density of the steam at that point, owing to the condensation that is constantly taking place. Of course, it will be understood that due allowance must be made when designing a pipe to admit of this reduction of area being made without impairing the usefulness of the pipe by stinting the engine of the required quantity of steam.

The following rule relative to the proper size of steam pipes is occasionally seen in engineering literature: *"To find the area of a steam pipe, multiply the area in inches of the engine cylinder by the speed of the piston in feet per minute, and divide the product by the mean velocity of the steam in the pipe, which is taken as 6,000 feet per minute."*

Expressed as a formula, it is:

$$\text{Area of pipe} = \frac{\text{area of cylinder in inches} \times \text{piston speed in ft. per min.}}{6{,}000}$$

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and from this the diameter of the pipe can be obtained by a simple calculation.

Care should be taken, in the placing of valves in the main steam pipe, not only to attach a sufficient number but to locate them with due regard to existing conditions and requirements. It should also be borne in mind that the best is none too good, when it is considered how important a junction that of a valve is. No valve that has any chance of becoming internally deranged should be admitted into the construction of a main steam pipe. A mere loosening of a nut within may cause considerable damage and make the entire valve inoperative.

Concerning the *number* of valves incorporated in a pipe, it may be said that enough should be admitted to provide for and protect against any contingency that may arise. It should not be necessary to depend on any one valve in a line of piping; any part of the pipe, the boiler, the engine, or any attachments should be accessible for hurried repairs by having a sufficient number of valves to operate. Especially is this applicable to a large plant where the shutting down of *all* the machinery, in order to make a repair to any unit, means a heavy loss to owner and employes alike.

In plants having large and long main pipes, the valves should be equipped with smaller valves, termed by-pass valves; these, as the name implies, permit, when opened, the steam to *pass by* the main valve without opening it. The object of these valves is to permit a reduced volume of steam to circulate through the pipe, as, for instance, when "warming up" before cutting that particular section of pipe into actual service. The operator has much greater control of the steam through the medium of these by-pass valves than he could possibly have with the main valves, and therefore the element of danger is considerably lessened if not entirely obliterated by their use. When it is remembered that much danger attends the admitting of a large quantity of steam into a pipe of large diameter and great length, where the pipe has not been in use for a period, the utility of the by-pass valve can readily be seen. The writer has seen instances where it has taken ten hours to warm up a steam pipe before it was considered safe to open the main valve and admit the full volume and pressure. The pipe referred to was 20 inches in diameter and several hundred feet in length.

The boiler stop-valves should not always be placed *on* or *close* to the boiler; the prevailing idea with engineers is that they should. Suppose, for instance, that a number of batteries of boilers are connected by smaller pipes to one or two large mains that are considerably higher than the highest point of the boilers; in that case the stop-valve should be placed at the point where the boiler pipe connects with the main. The reason for placing the valve at this end instead of at the boiler end is to preclude the possibility of the riser pipe becoming filled with water of condensation, which, in such a place, would cause other evils. Hence, it will be seen that all these points must be seriously considered in the design.

PUBLIC SERVICE OF RAILWAYS

THE number of passengers carried during the year ending June 30, 1899, as shown in the annual reports of railways, was 523,176,508, an increase for the year of 22,109,827. The number of passengers carried 1 mile—that is, passenger mileage—during the year was 14,591,327,613, an increase in this item of 1,211,397,609. There was an increase in the density of passenger traffic, as the number of passengers carried 1 mile per mile of line in 1899 was 77,821, and in 1898 it was 72,462.

The number of tons of freight carried was 959,763,583, an increase of 80,757,276 tons. The number of tons of freight carried 1 mile—that is, ton mileage—was 123,667,257,153. The increase in the number of tons carried 1 mile was 9,589,680,848. The number of tons carried 1 mile per mile of line was 659,565. These figures show an increase in the density of freight traffic of 41,755 tons carried 1 mile per mile of line.

The average revenue per passenger per mile for the year ending June 30, 1899, was 1.925 cents; for the preceding year it was 1.973 cents. The revenue per ton of freight per mile was .724 cent, while for 1898 it was .753 cent. An increase in mileage earnings is shown for both passenger and freight trains. The average cost of running a train 1 mile increased nearly 3 cents as compared with 1898. The percentage of operating expenses to earnings shows a slight decrease as compared with the previous year.

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COMPOUND-WOUND DYNAMOS IN MULTIPLE

(*Continued from the September, 1900, Number*)

Eug. C. Parham

EFFECTS OF HIGH RESISTANCE OR BAD JOINTS IN THE EQUALIZER—RUNNING MACHINES OF DIFFERENT CAPACITIES IN PARALLEL—EFFECTS OF DIFFERENCES IN CONSTRUCTION

A GLANCE at the conditions in hand will show how important it is that the equalizer be ample in size and free from bad joints, so that its resistance may be so low as not to influence the value of the equalizing current. Fig. 5 is the same as Fig. 4, except that most of the devices have been left out to simplify the sketch. Suppose the No. 1 dynamo to be in service, but the K_2 line switch to be out and the equalizer switch in. The current from the No. 1 dynamo then splits when it gets to point O_1; part of it takes the path O_1–F_1–X_1–X_2 through the No. 1 series field, and part takes the path O_1–K–O_2–F_2–X_2 through the No. 2 series field. If the resistance of the two paths is the same, the current through each will be the same; that is to say, if the resistance of F_1 and that of the stretch of positive bus-bar in between the points X_1, X_2 where the two dynamo mains are tapped on, is equal to the resistance of the F_2 field and that of the equalizer O_1 O_2, the same current will go through both.

In practice, the positive and negative busses are such heavy bars of copper, and the dynamo mains, where there are only two, are tapped on so close together that the resistance of the intervening stretch of bus-bar is practically nothing, so the actual requirements reduce themselves to the condition that the equalizer be made so large that its resistance, added to that of F_1, shall be the same as that of F_2 alone; or added to that of F_2, the total shall not appreciably exceed that of F_1 alone. In other words, the equalizer must be so liberal in cross-section that its resistance shall be practically zero, in which case, on machines whose series fields are of the same capacity and resistance, the equalizing current will be the same whichever way it may flow, under the condition that one line switch be open. As long as one line switch is open, the relative resistance of the two field circuits alone decide how much of the total current each will take. As soon as both line switches are in, however, the relative potentials of the two ends of the equalizer play a part, but the relative resistances still have a strong influence; for let the resistance of the equalizer be very high; as stated before, the current through the equalizer is due to a difference of potential between its two ends, irrespective of what the polarity of this difference may be. The amount of current that any given difference of potential can send through a given wire depends on the resistance of that wire. When the equalizing current flows toward the No. 1 dynamo, its resistance adds to that of the F_1 field, and when it flows toward the No. 2 dynamo, it adds its resistance to that of the F_2 field. In either case, the given potential difference at the ends of the equalizer cannot send as much current through it as it could if the resistance of the equalizer were less, so it follows that the series-field current of the lagging machine cannot get as much of a boost, and therefore the equalization is not good.

With the switch K open, the resistance of the equalizer is infinite, so that there is no equalization at all. With an equalizer whose cross-section is 6 or 8 times that of the wire used in the fields, and as short as possible, equalization is as perfect as the equalizer can make it. There is no reason why the resistance of the device cannot be brought down to a negligible value, just as that of the bus-bars is.

The importance of liberality in equalizer design seems to have been overlooked in many cases, and at times it has been necessary to resort to hand regulation. It must be borne in mind that the resistance of a series field itself is quite low, so that it is not a hard matter for a small equalizer, or a bad joint in a large one, to put an appreciable additional resistance in the path of the equalizing current and thereby impair the equalization. It is a very interesting experiment to connect a low-resistance ammeter across the equalizer switch and then open the switch and watch the antics of the current. If the zero point of the meter is in the center of the scale, so that the needle is

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free to go from one side of zero to the other, so much the better; sometimes it will show the current to be flowing in one direction and sometimes in the ther, and sometimes there is no flow at all.

The above talk is right in line with the second condition, under which compound-wound dynamos can be run together in multiple, even if they are not of the same

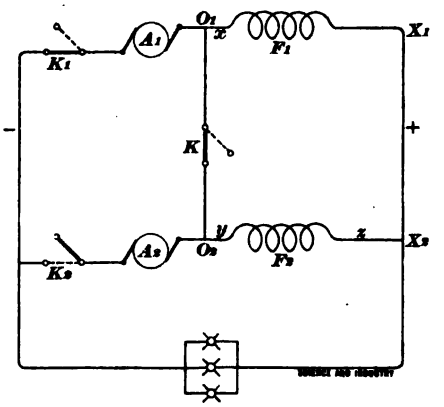

FIG. 5

capacity; that is to say, by means of the equalizer, a 100-horsepower dynamo can be run alongside of a 25-horsepower dynamo, and each will take its proportionate share of the load, whatever that load may be. However, one important condition must be fulfilled; the condition is this: If two compound-wound dynamos of different sizes are to be run together, in order that each shall take its own share of all loads, the resistances of the series fields must be inversely proportional to the capacities of the dynamos. In other words, if the resistance of the series field on a 100-horsepower dynamo is ½ ohm, the resistance of the series-field on a 50-horsepower dynamo with which it is to equalize should be twice as much, or 1 ohm; that of a 25-horsepower dynamo should be four times as much, or 2 ohms, because its capacity is only one-fourth that of the larger one.

As a rule, where several sizes of machines are turned out by the same designers, this proportionality in the resistances of the series field is observed so that the machines will equalize all right as dynamos; but where it is tried to run together two dynamos of different types, or not made by the same company, in the majority of cases they will refuse to share the load right. It is not intended to convey the idea that if the series-field resistances are properly proportioned the two dynamos are bound to equalize, for this is not so. In dealing with machines of different types and makes, one is apt to run against one other and more serious difficulty, to be taken up later.

If the want of proportionality in the series fields is the only reason why the two dynamos do not equalize, the trouble can be remedied in short order. Let the capacity of A_1, Fig. 5, be twice that of A_2. Suppose, for simplicity, that the resistance of the equalizer is zero; suppose also that the F_1 and F_2 fields are of the same resistance. As soon as K is closed, the two fields will take equal current, if one of the dynamos only is on the load. Since the wire with which the field on the smaller dynamo is wound is much smaller than that on the larger dynamo, the current that flows through F_2 when K is closed, with A_1 in service, might be sufficient to injure F_2, even though K_2 might never be closed to allow A_2 to do any work. Further, if F_1 and F_2 have the same number of turns in them, the field of the small dynamo will be disproportionately stronger than that of the larger one, on account of the disproportionately larger current flowing through it. If, as is apt to be the case, the smaller field has more turns in it than the larger one, the disproportion is even greater. In either case, for all loads, the smaller dynamo tends to overload itself, and the equalizer is never idle. To make the two machines share the load in anything like the right proportion, one of two things must be done: the field rheostat on the smaller dynamo must be constantly changed by hand, to meet the requirements of the shifting load, or the series field of the smaller dynamo must have put in series with it a resistance that will establish the proper ratio between the two windings.

On circuits that are subjected to sudden and violent fluctuations in load, as on a railway circuit, hand control would be out of the question, as the belts would give a great deal of trouble. Aside from this, there would be lost the most valuable property of a compound-wound dynamo—its automatic regulation—for a compound-wound dynamo will regulate for constant potential only when the field rheostat is adjusted for normal voltage on open circuit once for all, and left in that position, the series-winding providing the additional voltage necessary to look after load losses. The best way to even things up is to insert a resistance where it will establish the condition that the series-field resistances shall be inversely propor-

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tional to the outputs of the respective machines.

As an actual example, suppose that A_1 has a rated current output of 300 amperes and A_2 a rated current output of 100 amperes; let the resistance of the A_1 series field be .002 ohm; what should be that of A_2 in order for the two machines to equalize properly? Since the current of A_2 is one-third that of A_1, the field resistance of A_2 must be three times that of A_1, or $3 \times .002$ ohm $= .006$ ohm. Suppose that, instead of being .006, as it ought to be, it is only .0042 ohm; in this case it will be necessary to put in series with the A_2 series field a resistance of $.006 - .0042 = .0018$ ohm. This extra resistance brings the resistance of the A_2 field up to what it ought to be, i. e., .006 ohm. The resistance must be of ample size to stand the current without heating, and must be inserted at some such point as y or z, so that it will not be in the path of any equalizing current that might pass from the A_2 dynamo to the field of the A_1. On the other hand, if the field resistance of A_2 is too great or that of A_1 too small, the extra resistance must be placed in the field of A_1 at some such point as x, or between F_1 and X_1 where it cannot be in the way of an equalizing current passing from A_1 to F_2.

The third condition under which compound-wound dynamos are often run in multiple, and the condition under which they do not share the load well, nor can they be made to do so without going to great expense, is where the two machines are entirely different in nature, due to difference in design and material of construction. The two machines may be of the same output and their series fields may measure the same, and still they will refuse to share properly a variable load. This is due to a difference in the character of the magnetic circuits of the two dynamos, whereby a given increase in magnetizing current causes more increase in voltage on one dynamo than it does on the other. As an extreme case, suppose that one dynamo is made of cast iron and the other of wrought iron, and that at some particular total load they share the load properly. It is a well-known fact that a given magnetizing force will send more lines of force through a wrought-iron path than it will send through a cast-iron one, because wrought iron offers less resistance to the flow of lines than cast iron.

It is also a fact that the more lines of force there are going through a piece of iron, the harder it is to get any more through it —the iron gets in a condition called *saturation*. Now, cast iron reaches its point of saturation much sooner than a piece of wrought iron of the same dimensions, and, also, whatsoever the relative dimensions may be, the cast iron, almost in every condition or stage of its passage from the residual state to the state of saturation, changes its magnetism under a given change in the magnetizing current at a different rate from what wrought iron does. Also, one metal holds its residual magnetism better than the other metal does. The final result of such a great difference in the magnetic character of the two machines is that if an equalizing current of 5 amperes passes to one machine, it may send its voltage up 20 or 30 volts, while an equalizing current of 5 amperes through the machine made of poorer iron might send its voltage up only 5 or 10 volts, and perhaps less. The machine whose magnetism responds most freely to a given increase in the magnetizing current is the one that tries to take more than its share of the load.

How great will be the difference in the effect that a given equalizing current will have on the voltages of the two machines will depend on how near the magnetic circuits are to saturation, and therefore on how much of a load the two dynamos are carrying. In cases where the two dynamos are so unlike that they will not equalize the load, it is the custom to keep an eye on the field rheostat of the machine that shows the most tendency to overload and give it a turn when necessary; but under this condition it is impossible to get anywhere near the benefit of the full output of both machines, because when run near full load a sudden variation is certain to throw a belt. It is a much better plan to dispense with the use of the series fields entirely and run the machines as simple shunt dynamos. They will not then call for so much care and attention.

As stated before, in order to throw a compound-wound dynamo into service with other dynamos already under load, its shunt-field switch is closed, its voltage adjusted to normal value by means of the field rheostat, the equalizer switch closed, and last, the line switch is closed. To take the dynamo out of service, the reverse order is followed: the line switch is pulled first, then the equalizer switch, and last the field switch. Under no circumstances must the shunt-field switch be pulled while the line switch is in, if there are other dynamos

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on the load, for such a move reduces the voltage of the machine far below the point where the equalizer can supply the deficiency, with the result that the line backs a current through the machine, runs it as a motor, and in some cases tears things up in general. The same effects are caused some-

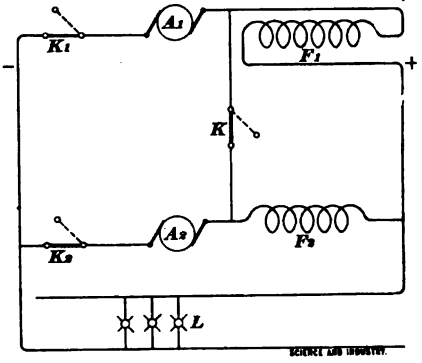

FIG. 6

times, but to a less degree, by putting in the line switch ahead of the equalizer switch, when a dynamo is cut in; or by pulling the equalizer switch ahead of the line switch when a dynamo is to be cut out. It must be borne in mind that in either case the machine has only its shunt field to defend its claim to a part of the load, and the shunt field is adjusted to give normal voltage only on open circuit, and cannot, therefore, supply normal voltage under any load. Also, if the dynamos are compounded to keep the voltage normal and constant at some point out on the line, the voltage across the bus-bars will be more than normal, because the loss on the line between the bus-bars and the removed point of constant potential must be looked after. The final effect of closing the line switch before, or opening it after, that of the equalizer, is, then, to throw the dynamo in on a line voltage that is higher than its own voltage and thereby to run the chances of the dynamo's being motored. Aside from the chance that the dynamo stands of being run as a motor, it is subjected to the usual liability of causing a belt to be thrown by the violent changes and shirking in the load that always attend any attempt to run two compound-wound dynamos in multiple without an equalizer, or rigid connection.

Another cause that will lead to a dynamo being reversed and run as a motor and in very short order with a series of demonstrations that will leave no room for doubt in the mind as to what is the matter if it has ever been seen before, is a reversal of the series-field connections. We have learned that the reversal of the series field on a dynamo that is alone on the circuit will result in the machine's refusal to take a load, because the main-line current acting through the agency of the reversed series coils neutralizes a portion of the lines of force provided by the shunt coils, with the result, to use a paradoxical expression, that the voltage is pulled down as fast as it is built up.

In Fig. 6, the series field F_1 is shown to be reversed, so that the current either from its own armature or from the equalizer will pass into it at the wrong end. If, on actual dynamos, the two ends of the series coils were as far apart as they are shown to be in the figure, there would be very little chance of getting them confused; but, as a matter of fact, the two ends are brought out to blocks that are right alongside of each other, so that if, for any reason, it has been necessary to disconnect the ends, it is not a hard matter to get them back wrong. Suppose, in Fig. 6, that A_2 is on the load and that A_1 must be thrown in. The voltage of A_1 is brought up to its normal value; the reversed series winding does not appreciably interfere with doing this, for, in Fig. 4, although the shunt-field current goes through the series coils, this current is so small and the number of series turns so small compared to the number in the shunt field, that their opposing effect is not felt. As soon, however, as the equalizer switch is closed, the equalizing current from the No. 2 dynamo goes through the F_1 field backward, so that instead of building up the voltage of A_1 for the load, it pulls it down to a value much below normal, and the effect of closing line switch K_1 is to run A_1 as a motor.

Dynamos of today are so designed that without shifting the brushes they will run from no load to full load, and in some cases even overload with little or or no sparking. Other machines, if the brushes are run well ahead, to suit the non-sparking conditions of a load, will spark badly if for any reason the load should go off with the brushes in this position, and in some cases will even flash over from one brush holder to the next one of opposite sign. Such behavior can be very much modified by adjusting the brushes as follows: When the voltage is being adjusted to normal value with the line switch open, the brushes should be run as far ahead in the direction of rotation as sparking will permit. Let the brushes spark

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on no load as much as you dare; then as the load goes on the sparking will disappear and will not occur within a wide load range.

If a fuse blows or a circuit-breaker flies out, or for any other reason the load gets suddenly dumped, you know exactly how much sparking to expect. This precaution is especially useful on carbon-brush 500-volt street-railway dynamos, whose load fluctuations are sudden and violent. It will not take a good dynamo tender long to find out that if the brushes are shoved ahead after the voltage is adjusted to normal value, the voltage will have to be adjusted again by means of the field rheostat, because the effect of moving the brushes out of the no-load neutral point is to change the no-load voltage. After readjusting the voltage, it may be necessary to change the brush lead again; they may spark too much or too little, and, therefore, in the last case, admit of more lead and better load regulation.

The effect of the brush lead on the dynamo's voltage becomes a great deal stronger as the machine takes a load. This fact forms the basis of one of the most deceiving "bugs" that can happen to a dynamo, whether it be a series-, shunt-, or compound-wound machine, and the "bug" takes place as follows: There is considerable friction between the brushes and the moving commutator, so that the latter tries to drag the brushes around in the same direction as it is turning; if the rocker-arm happens to be loose, so that it is free to turn, it will be dragged around slowly. The first symptom of such a condition is that the brushes begin to spark badly; as they move on around away from the non-sparking point, they spark worse, the voltage on the machine works down, the load works off, and the next thing that happens is a big explosion at the brushes. So great is the effect that a change in the brush lead has on a machine's voltage that sometimes when compounding machines in the testing room, the tester will get within 5 or 10 volts of what he wants and then do the rest by shifting the brushes. This is a very bad thing to do, for the chances are that the brushes are finally left in a place from which they will have to be moved as the load goes off, to avoid an explosion. Where there are two or more compound-wound dynamos on the same load, the position of maximum lead and normal voltage on open circuit should be marked on the rocker-arms so that all of the brush leads may always be the same in relation, and so that if one of the arms moves it can be seen at a glance. The commutators should be kept in good condition, and where the machine has a shunt on the series field, the shunt connections should be kept perfect.

This article would not be complete without touching on one condition where compound-wound dynamos can be run in multiple without an equalizer. A station full of compound-wound dynamos all in multiple can be regarded as a single large compound-wound dynamo, and as such can be run on the same load and in multiple with another station full of compound-wound dynamos, provided either of two conditions obtain: (1) There must be an equalizer run between the two stations, the same as it is run between any two compound-wound dynamos; (2) the resistance in the line and ground return between the two stations must be abnormally high. Where the two stations are any distance apart, fulfilment of the first condition would be out of the question, because the equalizer would cost too much. The second condition has been fulfilled several times, and stations thrown on to the same load ran smoothly, but of course such conditions are not economical and would never be subscribed to as a feature of an original design. The theory involved in the possibility of such running is that the line resistance is so high that even if one station were shut down and all of its line switches left in, there could be no excessive flow of current from the other station.

PLUMBERS' SOIL

MOST plumbers prefer to buy their soil already prepared; some, however, choose to make it themselves, which is done in the following way: A package of lampblack is mixed with water into a mortar; a kettle containing about a quart of water and a tablespoonful of good glue is heated until the glue is melted, when the liquid is poured into the lampblack mortar and the whole well stirred for about an hour while it is boiling. When cold, the soil should be of about the consistency of gelatine.

This mixture may be tested by painting a piece of sheet-lead with it; if it cracks when the lead is bent back and forth, there is too much glue; if it rubs off with the hand, there is not enough.

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CONSTRUCTING A SHEET-METAL CUPOLA

(*Continued from the September, 1900, Number*)

William Neubecker

LAYING OUT THE PATTERNS FOR THE COLUMNS—FORMING, ASSEMBLING, AND PUTTING IN PLACE—PREPARING FOR THE MAIN CORNICE

THE base mold for the cupola having been gotten out, the next step is to lay out and construct the eight columns forming the support for the dome. From Figs. 2 and 3, which were published in the July issue, it will be noticed that these columns are of considerable length, and that, besides having a molded base that rests on an octagonal plinth, they are provided with an ornamental capital, which forms the apparent impost supporting the heavy main cornice. In Fig. 18 is shown, at *C B S*, the upper profile of the base mold,

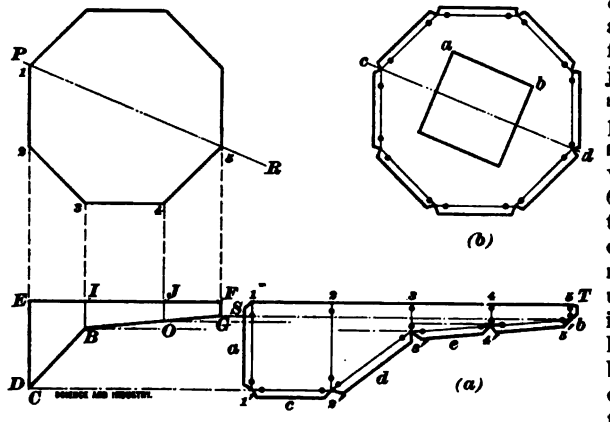

FIG. 18

or, rather, the wash of the cupola floor. In this figure, lay out in its proper position, which can be obtained from Fig. 3, the plan of the octagonal block, or plinth, that forms the foundation for the columns. Mark the corners *1*, *2*, *3*, etc., and through those designated as *1* and *5* draw the miter line *P R* dividing the octagonal figure into two sections. Project the corners of the octagon in plan on the elevation and draw in the line *E F* at the proper height. From the plan and elevation thus drawn, the stretchout for the plinth can be obtained as shown in Fig. 18 (*a*). In order to lay out this stretchout, draw the line *S T*, marking upon it divisions equal in length to the sides of the octagon. Mark these divisions *1*, *2*, *3*, etc., to correspond with those in the plan, and from them drop vertical lines as shown. On the vertical lines from *1* and *2* mark off a distance equal to *E D*, and from *3*, *4*, and *5*, distances equal, respectively, to *I B*, *J O*, and *F G*. Through the points thus obtained draw the lines *1′ 2′*, *2′ 3′*, etc., which will give the shape for the junction of the plinth with the top of the base mold, or wash. Allow for the laps *c*, *d*, *e*, etc., and cut out eight with laps at *a* and *b*, and eight more without these vertical laps. Form these sheets of metal, just shaped, on the small cornice brake, and bend the laps *c*, *d*, *e*, etc. toward the outside at right angles. The two halves forming each plinth are now joined in one by riveting and soldering, and are completed by putting in the octagonal bottom shown in Fig. 18 (*b*). Since the wooden uprights, which are of 6 in. $\times$ 6 in. stuff, pass through the columns, it is necessary to cut in this bottom a square hole made somewhat larger than the uprights. Care should be taken in laying out this hole to so locate it that the side *a b* will be parallel with the diagonal of the octagon *c d*. By making the hole 8 inches square, 1 inch all around is allowed for play, which in this case is ample. Upon the bottoms being soldered in with the laps inside, the octagonal plinths are completed.

The molded bases of the columns, the form of which is shown in Fig. 3, can be obtained spun, from dealers in pressed-zinc ornaments, or they can be made by hand, hammered out in the manner that will be described in connection with the lantern of this cupola. The ornamental capitals are stamped and are likewise obtained from dealers in this class of work. The length of the column after deducting the height of the base, 9 inches, and the height of the capital, 16 inches, is 7 feet 10 inches, and is the length necessary to consider in obtaining the patterns for the shaft. The columns, in order to have a good appearance, must be

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formed with the necessary entasis; this is sometimes secured by stamping or pressing the columns to the proper shape in sections and then soldering or riveting them together. The cupola we are considering, however, is situated at considerable height above the sidewalk, and consequently the columns can be formed in horizontal sections and worked out by hand, for at this distance the difference between the finer pressed work and hand work cannot be detected. To construct the column by hand, it is necessary to divide the elevation of the column shaft into three parts, the respective diameters of which can be found by measurement and are as designated in Fig. 19. Each of these sections is practically a cone having considerable height in comparison with its base; they are consequently developed in much the same manner as would be employed in laying out that geometric figure. With C as a center and a radius equal to $5\frac{1}{2}$ inches, draw the semicircle as shown in Fig. 19. Mark off on this arc six equal divisions, designating them *1*, *2*, *3*, *4*, etc. As the method of obtaining the pattern for each section is the same, only that for the one section $E\ F\ K\ L$ need be explained. Therefore let $E\ F\ K\ L$ in Fig. 20 be a reproduction of that portion of the shaft in Fig. 19. Draw through the centers A and C an indefinite vertical line upward and extend the sides of the section FE and KL until they intersect this line at B; this point B is the center from which to strike the pattern. With this point just obtained as a center, and radii equal to BL and BK, draw the arcs LD and KH. With the dividers set to the divisions into which the semicircle FK, Fig. 19, is divided, space off on the arc KH, Fig. 20, commencing at the point K, twelve spaces as shown, thus locating the point H, and from this point draw a line to the center B, cutting the arc LD at D. Then will $LDHK$ be the net pattern for the top section of the column; seams or laps must be allowed for riveting or seaming.

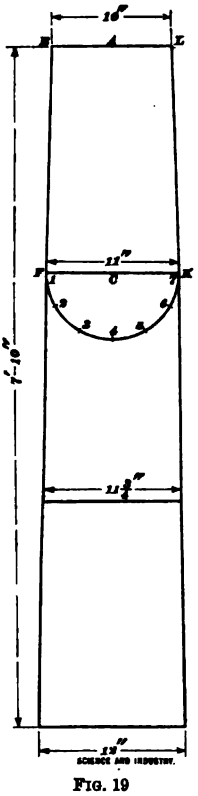

FIG. 19

As the seaming makes a better job, we will use that method of fastening in this case. If a $\frac{1}{4}$-inch seam is desired, as shown in Fig. 18 (*a*), it is necessary to add $\frac{1}{2}$ inch to the pattern as shown at *a b c*, Fig. 20. The mistake is often made by workmen, when laying out the laps for seaming, of allowing but $\frac{1}{2}$ inch for $\frac{1}{4}$-inch seams. It can readily be seen, however, from Fig. 20 (*a*) why it is that three times the given seam is required.

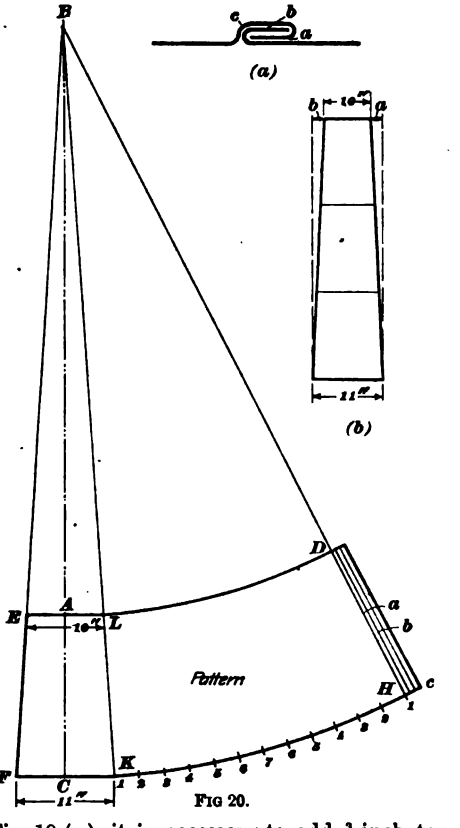

FIG 20.

When the patterns for the three sections have been obtained, eight sheets of metal similar to each will be required. The $\frac{1}{4}$-inch edges forming the vertical seams of the sections are bent up on the brake, and the section rolled in the 36-inch rollers, after which, by means of the mallet and groover on the mandrel stake, the seams are grooved and soldered. The three sections are now placed together so as to form one length, care being taken to have them in line, so that when completed the center of the top diameter of the column will

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be directly over the center of the bottom diameter. In order to determine whether such is the case, all that is necessary is to see that the distances *a* and *b*, Fig. 20 (*b*), are equal, measuring, of course, from a plumb line. These trial measurements *a* and *b* are taken at several points around the cylinder.

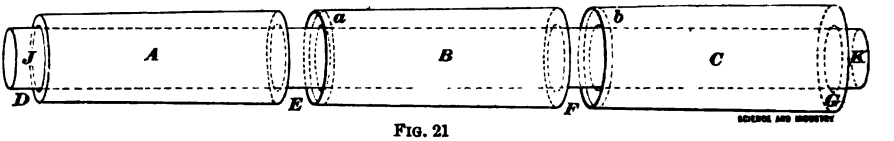

FIG. 21

Before the sections can be set up in one length, as shown in Fig. 20 (*b*), it is necessary to place sheet-iron bottoms in the ends of the sections. There will be four required, and they will be 10, 11, 11¾, and 12 inches in diameter, respectively. In the center of each describe and cut out an 8½-inch circle, which will allow the uprights to pass through the section. The 10-inch metal bottom is soldered in the top of the upper section *A*, Fig. 21, the 11-inch bottom in the upper end of the section *B*, and the 11¾-inch bottom in the upper end of the section *C*, while the 12-inch bottom is fixed in the lower end of the section *C*, as designated at *G*. Slip the sections upon a sheet-metal pipe made up in 24-inch lengths and about 8⅜ inches in diameter. Where the middle section *B* joins the two end sections, the bottoms are kept about ¾ inch from the end of the sheet, so that when

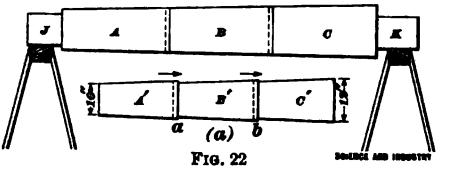

FIG. 22

the sections slip one within the other, as in Fig. 22 (*a*), a lap of this width will be formed. The laps must always be made as at *a b*, Fig. 22, so that they will shed water. After the sections are placed together with the pipe through the center, they should be supported on horses, as shown in Fig. 22, and the circumferential seams soldered by slowly revolving the shaft. The seams are finished by scraping and sandpapering.

The center pipe, or mandrel, is now removed, and the other seven columns assembled in a similar manner. The eight column shafts having been completed, the bases and capitals may be soldered to them, care being observed to see that the height of the columns is the same and is that called for by the drawing. Before the columns are erected, however, the octagonal plinths are secured to the molded bases and the columns are then ready to slip over the uprights.

Arrangements should be made with the framer so that he will not set the plates *P* and *R*, Fig. 2, and the braces *S* until the metal columns have been set over the wooden uprights. These uprights, being plumb and square, will hold the columns in the correct position, and the octagonal plinth will fit snugly the top of the base mold, or wash. It is sometimes the case that the metal columns must be put in position after the framing has been completed. When this course is pursued, bases and capitals must be made in halves and provided with lap joints, the soldering being done on the outside. This need not be done with the shaft, however, as it can be made in one piece with one seam, as shown in Fig. 23. In this figure, *a* and *b* shows the flanges turned on the edges of the sheets to form the lock. When setting the column around the wooden upright, it is sprung into the lock as shown, the seam closed tight, and a few rivets put in, as at *c d* and *e* to further secure it. When closing to form the double seam, blocking must be placed on the inside, to keep the lock from buckling inward.

The framer may now complete the structure and sheath the ceiling inside of the cupola, as shown in the section, Fig. 2. The blocking and lookouts for for the main cornice and dome are next put in place, finishing by putting up a 4½″ × 4½″ timber through the center of the dome to support the cross. The top of the dome and the top of the main cornice are likewise sheathed, the metal being placed on top of the sheathing and secured to it. In all work of this character the sheet-metal worker should furnish the framer with a tracing of all the details for the metal work, so that he can cut his blockings and prepare the sheathings to such dimensions that the metal work will fit well over the woodwork.

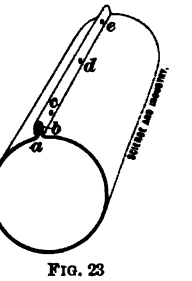

FIG. 23

(*To be Continued.*)

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FURNACES AND FIRING

C. P. Turner

IMPORTANCE OF PROPER AIR DISTRIBUTION—HOW TO SECURE A GOOD DISTRIBUTION. IMPORTANCE OF SIZE AND SHAPE OF FURNACE—STEAM IN THE FURNACE

THE solution of the smoke problem and the economical generation of steam must be accomplished by the intelligent cooperation of the fireman with the furnace designer; in order to make their labor effective, each must ever keep in mind the facts that the combustion of fuel is a chemical process in which the combinations of the elements always take place in certain fixed proportions, and that these combinations can be effected only when certain definite conditions are maintained. The conditions required must govern every detail of the design of the furnace, and the fireman must never lose sight of them if his part of the work is to be satisfactorily performed; in fact, the fireman who thoroughly understands the importance of maintaining the conditions demanded can often do much to offset the effects of defects in design, but no design, however meritorious, can secure good results in the hands of an incompetent fireman.

The fuel supply is, of course, the first factor to be considered in connection with the construction of the furnace and the management of the fire. The kind of fuel is generally fixed by the available sources of supply, and the work must always begin with this as a basis. Of equal importance with the fuel is the air supply. Since air is supposed to be free and the supply unlimited, its waste is not regarded as a serious matter, and the fact that its improper use means a corresponding waste of fuel is too often ignored. The complete and economical combustion of coal and the prevention of smoke depend upon a sufficient air supply—not an oversupply—and this air must be brought into intimate contact with the fuel to be burned. Without the proper distribution of the air, the high temperature essential for the combination of the elements cannot be maintained.

One of the best methods of supplying air to a boiler furnace is that in which the fire is thin and open enough to permit sufficient air to rise through the grate and fuel bed. The advantages in favor of this method are: the air, in rising through the fuel bed, becomes highly heated; if a clean even fire is maintained, the air supply is well distributed and comes into intimate contact with the gases almost as soon as they are formed, and the air and gas being thus thoroughly mixed in the vicinity of the hottest part of the furnace, complete combustion follows; the danger of chilling the boiler plates by a current of cold air is less than when the air is admitted at any point above the grates.

With this method of air supply, the firing must be carefully done—the fire must be maintained at a moderate and even thickness; the grates must be kept clean, and each air space must be kept as free from clinkers as possible; no bare spots should be allowed to form; and, finally, the coal should be supplied in small quantities and often, each shovelful being spread over as much surface as possible. Large lumps should always be broken up before being fired, and in no case should a thick mass of freshly fired coal be allowed to collect in any part of the furnace. Such a method of firing demands care and close attention on the part of the fireman, but if it is carefully followed the coal will be burned in a very economical manner and without the formation of black smoke. The reduction in the amount of coal that must be handled will, in a great degree, make up for the apparent increase in labor connected with such a system of firing.

The thickness of the fuel bed to be employed with this system of firing depends on the quality of the fuel and the intensity of the draft. In general, it may be stated that the best results will be obtained with a good strong draft that will permit of a fuel bed, with reasonably good bituminous coal, of from 7 to 12 inches in thickness. The thickness can best be determined by actual trials, carefully watching the results.

In a great many cases it is impracticable, or at least difficult, to regulate the fire so carefully as to secure a proper supply of air through the grates. For example, in locomotive work, where the demand for steam and the intensity of the draft are very irregular, it is found to be practically

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impossible to maintain a depth of fire that will conform to the irregularity in the conditions of running. The heavy currents of air drawn through the thin bed of fuel by the irregular action of the exhaust tear holes in the fire if it is kept too thin, thus allowing large quantities of cold air to enter at one place; these currents of cold air, in addition to their evil effects on the combustion of the gases and their chilling effect on the boiler, often carry considerable quantities of solid fuel into the flues.

It is seldom that the conditions are as unfavorable in stationary practice as in locomotive work, but there are many cases in which the irregularity of the draft or of the demand for steam are considerable. The quality of the fuel may also make it very difficult to keep a clean open fire that will allow of the steady air supply demanded; it is, therefore, often essential that means be provided for furnishing through openings above the grate at least a part of the air required to burn the gases. Of the methods used for this purpose, the one most commonly used is, perhaps, either a partly opened fire door or some special arrangement of openings through the fire door which serve as an inlet for the air and distribute it over the fire in a more or less satisfactory manner. A partly opened door must be regarded as one of the most unsatisfactory means of getting air into the furnace that could be devised. The air enters in a large stream and is more likely to cool below its ignition temperature the small proportion of the gas that it reaches than it is to promote its combustion; further, the concentrated current of cold air is almost sure to strike a limited section of the furnace and chill it; this in turn produces severe stresses in the boiler plates. Much more satisfactory results are obtained when the door is provided with special openings that serve to divide the entering current of air and distribute it over a considerable part of the grate. The perforated inner door is particularly useful in this respect; it serves the combined purpose of protecting the outer door from the heat radiated from the fire and of dividing the entering current of air into a great number of small jets that are considerably heated in their passage over its surface, and are then distributed to the fire through the perforations and around the edges of the plate.

With a large furnace it may be difficult either to admit sufficient air through the door to supply all parts of the furnace or to properly distribute the air so admitted. Various methods of introducing the supply at the sides of the furnace and at the bridge wall have been devised to remedy this defect. A few rows of hollow staybolts are sometimes used in locomotive boilers just above the surface of the fire; these admit air in small jets, which enter, at right angles to the current of the gases, that part of the furnace least likely to be reached by air from the door, and are thus more easily mixed with the gas than would be the case if the currents were parallel. Another method, intended to serve the same purpose in furnaces for externally fired boilers, is the use of hollow tiles, which lead air to the side of the firebox and deliver it in small jets through openings in the brickwork above the surface of the fire. In many cases the conduits through which the air enters are placed in positions that are intended to insure the heating of the entering air, which, when delivered at a high temperature, promotes combustion.

So far none of these special devices for supplying air to the sides of the furnace have been sufficiently successful to secure their extensive use. It seems that their advantages are much more apparent than real. There can be no great gain in any attempt to heat the air, since the quantity that must flow through a given passage will be so great that its temperature will be raised but little, unless the conduit is longer or the temperature to which it is subjected is greater than is practicable in the construction of most furnaces. Another point that would seem to be unfavorable to the success of any attempt to introduce air through the sides of the furnace, is the difficulty of controlling the quantity so introduced in accordance with the varying conditions of draft and fuel supply.

Numerous methods of introducing air through openings in the bridge wall have been devised, some of which have been put into more or less practical use. In many of these devices attempts have been made to heat the air so introduced by passing it through some part of the furnace or setting in which there is a high temperature. Such attempts, however, probably have never resulted in sufficient benefit to pay for the expense involved in the more complex construction of the furnace.

The admission of air through properly constructed openings in the bridge wall and above the fire has been shown by experiment to produce economical results when a

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bituminous coal, rich in volatile matter and producing a long smoky flame, is used. The openings through the bridge wall should be so arranged as to discharge the air in a number of jets at a right angle to the direction of flow of the gases. The space back of the bridge should then be large enough to form a combustion chamber in which there will be a thorough mixture and complete combustion before the air and gas are chilled by entering the tubes. A large space produces a relatively moderate velocity of flow of the gases, which is favorable to the intimate mixture of the air and gas.

While it would be an advantage to have the air enter at a high temperature, no means have yet been devised that will accomplish this in an economical manner. Of course, the temperature of the air is raised to a slight degree in its passage through the ash pit, the openings in the setting leading to the bridge, and in passing through the bridge to the openings through which it is discharged, but the actual gain by this means is relatively unimportant, even when rather elaborate systems of passages are used. Some of the difficulties attendant on this method are the following: In order to prevent loss from too much or too little air, the passages must be controlled by dampers, which should be regulated according to the condition of the fire and the rate of combustion; this demands close attention and intelligent care on the part of the fireman, who must either maintain nearly constant conditions in the furnace or change the dampers as often as there is a material change in the condition of the fire. The passages through the bridge wall may give trouble by becoming clogged with ashes and clinkers pushed back from the fire during cleaning or carried back by the draft, and so become useless. The method is limited in its application to furnaces so constructed that there is room for a combustion chamber of considerable size, in which mixture and combustion may take place before the gases are cooled.

The lowest temperature at which ignition of the gases can take place is about 1,800°. It is seen by reference to a steam table that the temperature of the water in the boiler, even under a pressure of 200 pounds per square inch, is less than 400°; this is practically the temperature of the surface of the boiler. It is therefore evident that any gas that comes into close contact with the boiler before being burned will be cooled below the point of ignition, and, unless subsequently heated, will be carried to the chimney unconsumed. With coals containing large quantities of volatile matter, and burning with a long smoky flame, it follows that the firebox must be of ample depth to provide a space in which the great volume of gas can burn before being cooled, or there must be a combustion chamber in which the gas can burn after leaving the firebox.

The danger of loss from cooling the gases too suddenly is greatest in internally fired boilers of the vertical and locomotive types. Unless the crown sheet is unusually high above the grate, vertical boilers are especially unfitted for the use of rich bituminous coals. Locomotive boilers, if properly managed, are better; by the use of the coking system of firing, the gas must pass back through the length of the firebox and over the hot bed of coke, thus giving it considerable time to burn before entering the tubes, the heat radiated from the coke helping to keep it at a temperature at which combustion is possible.

Many locomotive boilers are fitted with firebrick arches. These arches extend from the tube sheet toward the door, and force the gases to take a path first toward the door and then back above the arch to the tubes. The arch becoming highly heated, prevents the cooling of the gases before they become mixed with the air, and the path of the gases is lengthened sufficiently to enable them to burn before entering the tubes. The arches also lengthens the life of the flues by preventing the entrance of large volumes of cold air when the door is opened, and thus maintaining a more even temperature. The testimony of railroad men, almost without exception, is in favor of the firebrick arch for locomotives burning bituminous coals, and there is no doubt that the principle involved in its use can be employed in stationary practice to great advantage. Examples of modifications of the principle of the firebrick arch are seen in some of the automatic stokers now in use and in the furnaces of several of the water-tube boilers. In these furnaces, however, the position of the arch over that part of the grate nearest the fire door, while it helps to keep up a high and equable furnace temperature, does not materially aid in securing a more satisfactory mixture of gas and air, nor does it lengthen the path of the gas generated in that part of the furnace nearest to the boiler. Furnaces of this class are, for these reasons, best adapted to the coking system of firing.

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In internally fired boilers of the Cornish, Lancashire, Scotch marine, and similar types having large furnace flues that open into a chamber in the rear, the gases that are cooled by contact with the walls of the flue and pass through it unconsumed are sometimes burned in the rear chamber, which, for this reason, is given the name "combustion chamber." The combustion chamber, in order to be effective, should be provided with a mass of firebrick that can be maintained at a sufficiently high temperature to heat the gases to the ignition point. The currents of gases from the flues must then be brought into contact with this hot brickwork, and thus be burned before entering the tubes. These are conditions that are maintained with difficulty, especially in boilers like the Cornish, Lancashire, and Galloway, with long flues in which the gases are considerably cooled before reaching the combustion chamber.

With boilers of the return-tubular type, the space back of the bridge serves the purpose of a combustion chamber to a certain extent. The gases, however, tend to rise and flow along the cold surface of the boiler; it is, therefore, difficult to prevent a considerable body from thus becoming cooled below the ignition temperature and passing unconsumed into the tubes. Various arrangements of brick arches and flues have been placed between the bridge and the back end of the boiler, to overcome this difficulty, the purpose of these devices being to present heated surfaces of brick to the current of the gas and to promote the intimate mixture of the gas and air. Some of these arrangements are moderately effective, but they are subject to the limitations that were referred to in the case of the combustion chambers of internally fired boilers; that is, there is danger that the temperature of the brickwork will not be high enough to secure the ignition of any great proportion of the gases that pass beyond the bridge, or that much of the gas will not be brought into close enough contact with the hot bricks to be heated to the ignition point.

The construction of the type of furnace commonly used with water-tube boilers of the Babcock & Wilcox type is such that there is little opportunity for combustion to take place after the gases leave the firebox. The gases rise nearly vertically from the fuel bed and pass from the firebox immediately into contact with the tubes; the narrow spaces between the tubes divide the gases into thin sheets, which are rapidly cooled below the temperature of ignition. The vertical direction of the current of gases in the furnace makes it difficult to secure any considerable admixture of air from the fire door; the chief dependence for the air supply must, therefore, be on the air that rises through the grates and passes upward through the bed of fuel. These conditions make it essential, for complete and economical combustion, that a sufficient supply of air be admitted through the grate itself, and that the supply be well distributed over the whole grate area, so that it may become mixed with the gases almost as soon as formed. It is also important that the grate be placed far enough below the tubes to permit of a thorough mixture of gas and air and of complete combustion of the gas before it enters the space between the tubes. The distance from the grate to the tubes should be regulated in accordance with the volatile contents of the coal; for anthracite or coke, the minimum distance is about 24 inches; for coals containing large quantities of volatile matter and burning with a long flame, a distance of 36 inches or more is often needed.

A study of the construction of the furnaces of most water-tube boilers, and of the mechanical stokers generally used for burning bituminous coals, will reveal the fact that a large combustion chamber, often covered by a firebrick arch for maintaining a high temperature and shielding the burning gases from the cooling effect of the surface of the boiler, is almost universally employed. It is urged by some authorities that a construction that separates the hydrocarbon flame from the heating surface of the boiler is a serious disadvantage in that a large part of the heat of such a flame is given up to the boiler by radiation from the incandescent carbon particles, while a colorless flame radiates but little heat and gives up heat to the boiler almost entirely by direct contact. It is certain, however, that the carbon particles may easily part with so much heat by radiation as to be cooled below their ignition temperature and so pass off unconsumed, with the consequent formation of black smoke; on the other hand, such an arrangement of the heating surface is possible as will enable all portions of a hot current of colorless gas to be brought into sufficiently close contact with the surfaces of the boiler to give up its heat in a thoroughly effective manner. It is probable that herein lies much of the effectiveness of the heating

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surface of the water-tube boiler; the gas passes in thin sheets between the staggered rows of tubes or around the various baffle plates, thus inducing cross-currents that force every portion of the gas into close contact with some part of the heating surface.

When steam is admitted into the furnace through the ash pit or otherwise, it is decomposed by the heat into its constituents, hydrogen and oxygen. This process, however, absorbs as much heat as can possibly be developed by the combustion of the hydrogen thus formed. From this it follows that there can be no possible gain in heat from introducing steam. In fact, there are several features that may cause the use of steam to result in an actual loss of heat: there is danger that much of the hydrogen liberated by the decomposition of the steam may escape unburned, owing to the reduction of temperature of the fuel bed produced by the decomposition of the steam. There is also another loss: the steam enters the ash pit at a temperature seldom above 212° F. and passes into the chimney at the temperature of the flue gases, which is rarely below 400°. It thus carries more heat into the chimney than it introduces into the furnace.

The use of steam or water under the grate is, however, beneficial in some cases. With coals that tend to clinker badly and stick to the grates, the effect of the steam is to prevent the clinkering to a considerable extent. This enables the fireman to keep the grate cleaner, prevents the destruction of the grate, and, on account of the improved condition of the fire, permits of a better distribution of air and more complete and economical combustion. In the case of the Argand blower and similar devices for securing an increased draft, there is often an increased economy in the use of coal over that which is obtained by natural draft; the gain, however, must be ascribed solely to the improved air supply, and not to the fact that steam is used. A similar improvement in the draft, by means of a better chimney or some mechanical-draft appliance, will generally give even better results than can be obtained by the use of steam. If a steam blower must be used to improve the draft, it should be so constructed and operated as to introduce as little steam into the fire as will secure the requisite air supply.

Having seen that complete, i. e., economical, combustion depends upon a sufficient air supply intimately mixed with the combustibles and a high furnace and combustion-chamber temperature to insure ignition, the following rules will be self evident:

1. Fire light and often.
2. Keep the fire as thin as circumstances permit.
3 Keep the fire clean.
4. Keep the space between the grate bars clear.
5. Keep the ash pit clear.
6. When using bituminous coal, use the coking-firing system, if possible.
7. Regulate the draft so that it will be strongest when a fresh charge of coal is put into the furnace.
8. Do not let the fire burn out in spots.
9. Do not let the fire burn too low before charging.
10. If possible, fire at regular intervals and in regular charges.

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FLATS, OR APARTMENT HOUSES

Thomas E. McNeill

DESCRIPTION OF THE HEATING SYSTEMS—COMMON SIZES OF THE PIPES—THE CONVENIENCES OF A MODERN FLAT

FLATS, or apartment houses, have long been used in European countries, and in America a few private houses have been utilized for many years by small families for "room keeping," but only within the past twenty-five years has any effort been made to make apartment houses a distinct feature in this country. The hotel or boarding house was the refuge for city dwellers who did not own their houses; and the tenement house, or "death trap," was the only resort for the humble class.

The great convenience and comfort of well-arranged flats can be fully appreciated only by those who have lived in them. The rooms being generally all on one floor, or level, the fatiguing labor of climbing up and down stairs is avoided; all supplies required are sent up from the basement by elevators, or dumb-waiters as they are called; and all handling of these supplies in the hallways is avoided. In the more elaborate and expensive houses the passenger elevators make all floors alike, as far as ease of access goes; in fact, the upper floors are in many respects preferable. The introduction of elevators necessitated some form of power to operate them. This, at first, was steam power, direct or through pumps (hydraulic pressure). Both required moderately high steam pressure to be carried in the boilers. The exhaust steam, if sufficient, was used entirely in heating the houses; when it was not enough it was supplemented and at times superseded by steam reduced in pressure taken direct from the boilers.

The electric elevator has largely superseded the others, when current can be had from the street. It obviates the necessity of carrying high pressure in boilers and allows an ordinary low-pressure steam-heating apparatus to be used. When the electric current for lighting and power purposes is generated in the building, the same system of heating is used that is adopted when steam or hydraulic elevators are employed.

In some of the most expensive apartment houses a combination of the indirect and the direct radiation system is used, the first, second, third, and even the fourth stories being indirect and sometimes with circulation accelerated by a fan. The system used on the upper floors is, when possible, the semi-direct or direct-indirect as it is called. Of course, where properly arranged and used, the combined system, with a forced circulation of air by a fan, is near perfection, because both the heating and the ventilation can be regulated by the occupants of the rooms. The first cost and maintenance of such a system must, of course, be duly considered. The house construction and many other points, such as hot-air-flue space in the walls, and ventilating flues in the partitions, etc., must also be considered. The present style of skeleton steel construction, in which the loads are carried by the framework and the walls, are mere curtains or enclosures of brick, stone, or other partly non-conducting materials for keeping out the rain storms or for ornamenting the exteriors, offers some advantages, but in such buildings ample provision must be made, by increased heating surface, to compensate for the rapid escape of heat through the thin walls.

The direct-indirect system of heating has all the advantages of the direct, and it furnishes, at the same time, a supply of fresh warm air. Where provision has been made in the walls, partitions, or even over the doors for the escape of vitiated air, this system adds greatly to the health and comfort of those occupying the apartments on the north and west sides, as the pressure of the air currents coming from that quarter, in winter, forces the air up through the radiators into the rooms. On the east and south sides, there being little or no wind pressure, it is not so efficient, but is better than the direct radiation alone, as generally used without provision for air renewal and ventilation.

The following is a description of the heating system in a certain apartment house of the medium class that is well heated by direct radiation as it is called—that is, by radiators located in the rooms to be heated—the steam pressure not exceeding 10 pounds per sq. in. The amount and kind of heating surface in each room is in

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proportion to its cubic contents, exposure, etc. The radiators used are of the vertical sectional class; each section 38 inches high contains 4 sq. ft. of heating surface, each one 32 inches high contains 3⅓ sq. ft., and each one 26 inches high contains 2⅔ sq. ft.

On the first story there are two front parlors, each containing 12 sections, 26 in. high = 32 sq. ft.; two libraries, one containing 8 sections 26 in. high = 21⅓ sq. ft., the other containing 6 sections, 26 in. high = 16 sq. ft.; two bedrooms each containing 9 sections, 26 in. high = 24 sq. ft.; two bedrooms, one containing 8 sections, 26 in. high = 21⅓ sq. ft., the other containing 7 sections, 26 in. high = 18⅔ sq. ft.; two dining rooms, each containing 8 sections, 38 in. high = 32 sq. ft. In the entrance hall there are two radiators of 10 sections, 38 in. high = 40 sq. ft. each. All these make a total of 333⅓ sq. ft.

On the second and third stories there are four outer parlors, each containing 6 sections, 32 in. high = 20 sq. ft.; four inner parlors, each containing 7 sections, 32 in. high = 23⅓ sq. ft.

On the fourth, fifth, sixth, and seventh stories there are sixteen parlors, each containing 8 sections, 26 in. high = 21⅓ sq. ft.

On the second, third, fourth, fifth, sixth, and seventh stories there are twelve libraries, 6 containing 7 sections, 26 in. high = 18⅔ sq. ft., and 6 containing 8 sections, 26 in. high = 16 sq. ft.; twenty-four bedrooms, each containing 8 sections, 26 in. high = 21⅓ sq. ft.; and twelve dining rooms, each containing 8 sections, 38 in. high = 32 sq. ft. The total on the seven floors, including the entrance, is 1,952 sq. ft

The risers that supply the radiators are mostly 2-inch to the fifth story, 1½-inch to the sixth, and 1¼-inch to the seventh. Some, however, that only supply the radiators in small rooms, such as the libraries and bathrooms, are 1¼-inch the full height. These are all two-pipe risers, the return risers being one size smaller. If they were single-pipe risers they would be one size larger, with 1¼-inch outlets on each story. The outlets for the double-valved radiators are tapped 1 inch for steam and ¾ inch for return, with a valve in each connection with the risers.

The steam mains are run in the basement, beginning with a 5-inch main at the boiler, and reducing and branching to supply all the risers and radiators. A 5-inch valve is placed on the main near the boiler, and a valve is located at the bottom of each steam and return riser, to shut off same for repairs. Drips at the bottom of these pipes are not necessary if the riser connections are properly made. The return mains are run below the water line of the boiler. They are one size less than the corresponding steam mains. A gate valve and swing check valve are attached to the return main near the boiler. Relief pipes are taken from the ends of the steam mains and are connected to the return mains below the water line. Air pipes are run alongside of the risers and are connected to the air valve on each radiator. They are carried down and discharged into a sink in the basement. Automatic air valves are often used without pipe connections, but they must discharge the air from the radiators into the rooms. This has often the odor of iron rust, which is objectionable to many persons.

The boiler used for generating steam for heating these flats is of the cast-iron vertical sectional type, and contains 315 sq. ft. of fire, or heat-transmitting, surface, and 15 sq. ft. of grate surface. The elevator is operated by an electric current from the street. The pump used for forcing water up to the tank on the roof is generally driven by steam of low or moderate pressure or by electricity.

A separate tank or a small boiler or stove in the basement is used for heating water to supply all the plumbing fixtures in the flats. In the best equipped modern flats all of the cooking is done with a gas range or stove.

A good reliable system of filtering the water used is an important addition to the general equipment. With every requirement supplied and near at hand, the difficulties and annoyances of house or "flat keeping" are reduced to a minimum.

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THE SPARK THAT KINDLES

Shah Jehan

MAN CHARACTERIZED BY HIS USE OF FIRE—HIS FIRST KNOWLEDGE OF FIRE FROM NATURE'S KINDLING—METHODS OF STARTING FIRE

MANKIND is distinguished from the rest of animal creation by the fact that he makes use of implements other than the natural members constituting his physical anatomy, and he only is entitled to the appellation of tool-using animal. But, after all, can this be said to be a distinguishing characteristic of man? The giant gorillas of Africa have been known to use clubs and their brethren of a smaller species to hurl missiles as in defense or to use stones with which to break the hard shells of coconuts, and even elephants have been observed to use boughs of trees that they have broken off in order to brush the leeches from their backs. Would it not be well, then, to look for some action or habit in man's mode of existence that would be peculiar to himself and of such a nature as to entirely preclude its usurpation by other animals?

What title could we find that would be more appropriate than that of fire-making or fire-using animal? Surely no other creature than man has been known to create the chemical phenomenon of rapid combustion that we call fire. Another fact that testifies strongly for the plea of his immutable right to this title is that there is really no authentic record of a fireless tribe, that is, a race of people to whom fire was unknown and who were not familiar with at least several of its uses and with a means of kindling it, however crude. It is true that several writers have made statements to the effect that such a people existed. In fact, no less an author than Padre Gobien states in one of his writings, "Magellan, wroth at the pilfering of the inhabitants, burnt one of their villages. When they first viewed their wooden huts ablaze, their thoughts were that the fire was a beast that eats up wood. Some of them having approached too near were burnt, and the others kept aloof, fearing to be torn or poisoned by the powerful breath of the terrible animal."

The inhabitants referred to are supposed to be those of the Ladrones, but from other and probably more reliable records it would seem that these people did have the knowledge denied them by Padre Gobien, whose accounts in this particular instance are looked upon with much doubt.

There must have been, however, a time when primeval man was unacquainted with fire—a time before the first steps in human progress had been made—and it was only when the first spark had been kindled that man truly began to stride toward civilization. How he must have wondered as he gazed upon those writhing flames of the first fire roaring and crackling and gathering strength as it reached out for more material to satisfy its almost insatiable desire for food. At first it was with fear and awe that he looked on this strange thing, so unlike the wild prey or savage beasts he had hunted or encountered in the primal forest. But curiosity (for man was always curious) prompted him to go nearer the fire, and far from being harmed by it, he found the warmth pleasant in the chilliness of the approaching evening, and as the night drew apace its glow was grateful, for it mitigated the terrors of darkness and inspired fear in the wild beasts, his natural enemies.

Some strange intuition seemed to tell him that fire was for him only, and that by his control of it he would become superior to all creation. So he cherished it as he would a gift of great value, and when it became dull and died down for the want of fuel he fanned it to life and brought sticks and brush that it might burn with renewed energy.

The fire that man first knew was kindled by nature. The molten cinders or lava from a volcano flowing down the mountain side and setting fire to the copse at the base; the lightning stroke in the dry underbrush of the forest; the sparks from stones when struck by the hoofs of wild cattle hurrying through the dry grass of a prairie, or even the focusing of the sun's rays by a dew drop globule of balsam on some dry bit of fungus conveniently placed by nature, are all causes that might have—in fact, must have—acquainted mankind with fire.

Owing to the mystery surrounding the origin of fire and on account of the sacredness with which it is held by all heathen

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nations and tribes, many curious and usually interesting stories have been woven from the dreams or fancies of some medicine man or barbaric priest regarding man's first discovery of his greatest blessing. Several of these tales will suffice to show their visionary aspect and also to show the reverence with which the gift of fire is looked upon even at this day by the crude people who inhabit the uncivilized portions of the globe.

The Maories say that the fire was given to Maui by his old blind grandmother Mahnika, who drew it from the nails of her hands. Maui, however, wishing a stronger fire, deceived his grandmother into believing that the fire had been extinguished, and so he obtained more from her great toe. It was so fierce that everything melted before its glow; it commenced to burn Maui and even the grandmother herself, but fortunately a deluge sent from heaven saved them from perishing. Before the water had quite put out the blaze, Mahnika sent a spark into some trees, from whence man draws it now.

The native Australians have a similar story that is equally as crude and strange, for it proceeds somewhat like this: In a time long since passed away the only creature that possessed a firebrand was a little bandicoot, which prized it highly and guarded it carefully, finally becoming so selfish in its use as to refuse to share it with the other animals. Putting up with this state of affairs as long as they could, the other animals concluded to hold a general council, in which they decided that the firebrand must be obtained from their selfish companion either by cunning or by compulsion, and deputed the hawk and the pigeon to carry out the resolutions. After vainly trying to induce the owner of the firebrand to share his blessing, the pigeon, as he thought at an opportune time, made a rush for the prize. The bandicoot seeing that a crisis had been reached, and preferring to lose rather than share, threw the brand into the river, hoping to quench it therein. But fortunately for the black man, the hawk, sharp-eyed and ready, hovering near, with a stroke of his wing sent the brand out of the water into the long grass upon the banks of the stream, which, being dry, ignited and the flames spread over the country. The black man then felt the fire and said it was good.

So it is that a deep mystery surrounds the operation of man's first fire getting; but no matter what method he employed, it was a long and weary road he traveled from that time until 1840, when the phosphorus match became general. Man might have unwittingly, in a wild chase for game, which he usually slew by a well-aimed stone, struck fire when the missile glanced along the edge of some forest boulder. Seeing the spark, he would naturally repeat the experiment with more or less success, and finally, by using two pieces of rock, one in each hand, would strike sparks at will. From this it was only a step until he learned to know that he could attain more success with certain kinds of rocks than he could with others. As he became expert in striking sparks he found that they would, upon falling on a piece of sun-cracked pith or bit of fungus, kindle a blaze. It was in some such way as this that all means of producing fire by percussion originated, and out of this grew the flint and steel, or "strike-a-light," of colonial days. At this day such a method of kindling is much used by the Eskimos, the northern Indians of America, and the Burmese, and it is known to all people.

"THE UPRIGHT STICK IS LIKE A DRILL RAPIDLY WHIRLED TO AND FRO BETWEEN THE HANDS AND AT THE SAME TIME PRESSED FIRMLY DOWNWARD"

The Eskimos use flint and pyrites to kindle fire by striking or scraping them together until small particles of the pyrites are heated to a dull-red heat, when they are dropped into some convenient tinder, which is thus set aglow. The Alaskans make fire in a very similar manner, by striking together two pieces of quartz over some grass or moss strewn with feathers, the quartz having been previously rubbed with sulphur. The inhabitants of Burma kindle a blaze by striking together a piece of china and bamboo, the silicious surface of the latter emitting a spark when so struck.

That friction will create warmth, and if long continued will generate heat sufficient to kindle a glow from which a blaze can be started, is known to nearly all primitive peoples, and the means employed to produce

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fire by friction may be distinctly classed as of three kinds, namely, by reciprocating motion, by sawing, and by plowing.

The simplest method of producing fire by reciprocating motion is by the two-stick apparatus that is extensively employed by the American Indians, by Africans, by Australians, and by other peoples not so well known. This method, which is the crudest and at the same time the simplest of all primitive means, is best described in the words of Livingstone, who says, in speaking of the Zambesi people: "These carry, on a long journey, a sleeping mat and a wooden pillow, a pot and a sack of meal, a pipe and tobacco pouch, a knife and a bow and arrow, as well as two little sticks two or three feet long, in order to make fire if they are obliged to spend the night away from human dwellings. Dry wood may always be found. In one of the sticks, which has a very rough outside and a little pitch within, is cut a notch and this notched stick is laid horizontally upon a knife blade placed on the ground. He who will make the fire squats down, and in order to hold the stick firmly puts his great toes at each end. He takes the other stick, which is of very hard wood and on which a very dull point is cut, and puts it squarely in the notch. The upright stick is like a drill rapidly whirled to and fro between the hands and at the same time pressed firmly downward. In the course of about a minute the friction ignites a part of the pitch of the notched stick, which as glowing charcoal runs over onto the knife blade and is brought into a handful of dried grass, which, by careful fanning, is kindled. It is a sore task to make fire in this way and soon raises blisters on white hands." This method seems to be identical with that employed by the Hupa Indians, of California, with the exception that they hold the stationary stick by their knees to prevent it from turning.

"THE ESKIMOS HAVE DEVISED, FROM THE SIMPLE APPARATUS OF THE CORD-ROTATED STICK, A SOMEWHAT INGENIOUS MACHINE THAT CAN BE OPERATED BY ONE PERSON"

This method, though so simple, was very laborious and required considerable knack. In many localities it was greatly improved upon by wrapping a cord or piece of thong or sinew around the upright stick, which was pivoted in a block of wood or bone and was revolved rapidly by moving the cord back and forth. Two persons, however, were required to operate this arrangement, one to steady the top of the stick and the other to draw the cord.

Even the crude people of the uncivilized races are bound sooner or later, from their inherent aversion to work or because of necessity, to institute improvements in their primitive methods and customs. It is not surprising then to find that the Eskimos have devised, from the simple apparatus of the cord-rotated stick, a somewhat ingenious machine that can be operated by one person and used either as a drill or for kindling a spark; they have, in fact, produced, in a crude form, a bow similar to that employed by jewelers to turn lathes and drills.

"IT ONLY REQUIRES A DOWNWARD PRESSURE ON THE YOKE TO SET THE VERTICAL STICK SPINNING AT A HIGH RATE"

This fire-making apparatus of the Eskimo is surpassed by the pump drill, as it is called, of the Iroquois Indians. This drill is undoubtedly the most efficient tool used for fire making by reciprocating motion, and is, in fact, the

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quickest and easiest means of producing fire by friction. The whole affair is simply a means of rotating a vertical spindle at a high speed and with considerable pressure. It consists of a round stick about 20 inches long, which is held vertical and is provided with a heavy wooden disk fastened near the lower end and a yoke consisting of a piece of wood about a foot in length having a hole in the middle of it large enough to admit the stick; the apparatus is completed by a piece of thong passed through a hole in the upper end of the spindle and secured to the ends of the yoke. A turn or two of the disk winds the thong around the spindle, and it only requires a downward pressure on the yoke to set the vertical stick spinning at a high rate. When the yoke, or cross-stick, has reached the lowest point in its movement the momentum of the wooden disk rewinds the thong and raises the yoke; another downward push sends the spindle revolving in the opposite direction with renewed energy. A few seconds of this is sufficient to raise a cone of sawdust at the lower end of the spindle where it rests upon the block of wood. The sawdust soon begins to smoke and finally to burn. It requires two to operate this device, but the ease with which a fire is kindled, when compared with the less ingenious methods, amply compensates for this disadvantage.

THE PRINCIPLE EMPLOYED BY THE PERUVIAN SUN WORSHIPERS

There are still two other means of kindling fire by friction that have as yet not been considered: fire making by sawing and fire making by plowing. The former of these is much practiced by the Malays and Burmese, while the latter method is used by the Polynesians, Australians, and Papuans. Kindling fire by sawing is accomplished by using two pieces of bamboo, one of which is a sharp-edged piece like a knife, and this is drawn rapidly across a convex piece in which a notch has been cut until it is nearly severed. By persistent sawing the convex piece of bamboo is finally pierced and the heated particles, falling below and under the hollow of the stick, are ignited. Rubbing or plowing out fire is a laborious operation, for the reason that the operator's efforts to produce sufficient friction are spread over a considerable area, and it consequently takes great pressure and a longer time. In rubbing or plowing out fire a stick some 18 inches long with a blunt point on one end is rubbed rapidly in a groove cut in a larger piece of wood set on the ground.

That it was possible to draw fire by simply rubbing two pieces of wood together was always a wonder to the savage people who employed such a method, and fire kindled in this manner was looked upon as sacred. In fact, among many of the North American Indian tribes the apparatus by which fire is kindled by friction is held in the greatest reverence, and an unpardonable sin would be committed if a brave were to show the white man how it was constructed or explain its use to him. So it is that in the same tribe three methods of kindling are known and practiced, the younger generation using the phosphorus match, the older generation the flint and steel, and the medicine man only the bow drill or the spindle to kindle the fire at the great sacrifice of the white dog, a yearly festival extending over six days.

The kindling of fire by friction was not confined to the uncivilized people of America, Asia, Africa, and Polynesia, for it was, on special occasions, used throughout Europe and in Scotland. In Germany as late as the seventeenth century "wild fire" was started when murrain broke out among the cattle and the herds suffered much damage. According to the superstition of that day, no other fire must be lighted at the time and the spark must be obtained in a peculiar way. An oak post with a hole through the center was driven into the ground and a windlass smeared with tar and pitch was inserted in the hole and turned until a blaze was started. Brush, straw, and wood were then brought from each house and ignited, the horses and cattle being hunted through it two or three times with sticks and whips. In Scotland such a fire as this is called a "need fire," and was kindled for a similar purpose as late as 1840.

Distinct from all the methods of fire making enumerated is that employed by the Peruvian sun worshipers, who, upon their recurrent festivals held at the period

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of the summer solstice, kindled their sacrificial fire by the sun's rays. For this purpose they used a concave mirror of polished metal, which collected in a focus the rays of sunlight and thus kindled the sacred flame by setting fire to a heap of dried cotton.

How much, then, must the misery of the savage have been increased without these crude means of fire making? How far from accomplishment would the civilization of today have been without the knowledge that gave to man the power to create fire at will and in consequence placed him superior to all terrestrial life. If we stop to think for a moment we become astounded at our dependence upon this same fire. Without it the metallurgic arts would be undeveloped, and instead of our great shops and factories with their powerful and quick-moving machinery our only tools would consist of a few stone mauls or axes pounded and chipped into shape and our only weapons sword blades or spear heads wrought from the native copper. All motive power, such as steam or electricity, would forever remain undiscovered, or at least impracticable; and no long railroad trains would wind across the prairies or engines puff their noisy way along some mountain side, nor would the ocean greyhound swiftly cleave its path through the unfathomable deep. Our morning meal would be a cold repast indeed, and shivering under a rough lean-to of brush, we would look toward the east for the rising of that dazzling disk of warmth, the sun, ever awaiting the discovery of fire, so that we might take the first step toward perfect civilization, wholly desirable but ever unattainable.

PURLIN CUTS FOR A CONICAL ROOF

Constructor

A Method for Determining the Curved Edge, Bevel, and End Cuts of a Purlin in a Conical Roof

THE American mechanic, when called upon to get out an unusual or difficult piece of work, exercises that independence which is his birthright and endeavors to obtain by his individual efforts the best and quickest solution of the problem before him. The framer or joiner doing the average work about town is often brought to a standstill by running up against work that is entirely new to him.

One of the problems that offers some difficulty to those who have not done similar work is that of cutting the purlins for a conical roof. The carpenter or framer would soon obtain the pattern for a roof of small dimensions directly from the work by means of the bevel square and a piece of line or measuring stick. Where there are several such roofs, however, of the same dimensions, or where the roof is of considerable extent, the foreman of the job or the master carpenter might desire to lay out the purlins accurately by means of a diagram, so that they could be cut and prepared at the mill, ready to be put in place. Suppose, for some such reason, it is desirable to obtain the cuts for the purlins shown in the conical tower roof, Fig. 1, which, while having the appearance of complexity, is really very simple.

The first step in laying out the diagram, Fig. 2, is to draw the elevation, that is, mark out the base and the slope of the roof. Project from this elevation the plan and lay out upon the plan the correct positions of two rafters, the center lines of which are shown at bc and ac. The section of the purlin should be drawn in its true position with reference to the slope, as at $f'd'h'g'$ in the elevation. In this case —and it is usually so—the face of the purlin is perpendicular to the slope of the roof. Where the purlin is placed thus, at right angles, or perpendicular to the slope in a conical roof, the upper and lower faces of the purlin lie in oblique cuts or sections through the cone. When a cone is cut in this manner the figure of the section is always an ellipse. In order to determine the shape of the purlin on the face and ends, so that its outer edge will lie in the roof plane and that it will fit neatly to the rafters at either end, it is necessary to determine the dimensions of the ellipse forming the sectional cut through the cone made by the oblique plane in which the face of the purlin lies.

Bearing these points in mind, proceed with the diagram by projecting from the plan the point a on the base of the cone, as at a'.

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Connect a' with the apex of the cone c', and the line so drawn will represent the inner edge of the rafters in the elevation. It is evident from what has been said that the

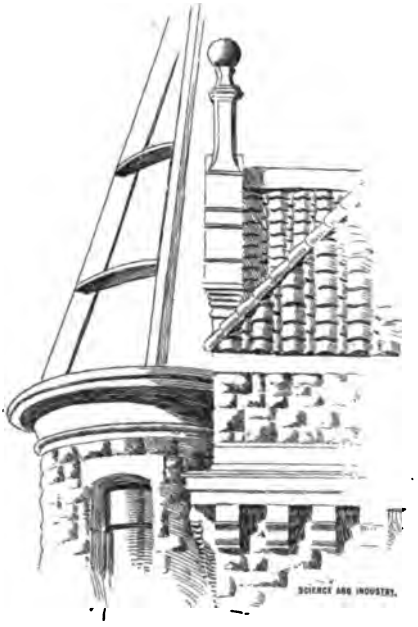

FIG. 1

curve of the outer edge of the purlin will be the same as the curve of the oblique section through the cone, at the same position as that in which the purlin lies. It is therefore necessary to find the curve of the conical section $h'q'n'$, in the elevation, Fig. 2, and in order to do this all that is required is to obtain the lengths of the semi-major and semi-minor axes, or the distances $h'j'$ and $j'n'$. The position of the point j' is readily found by bisecting the line $h'i'$, and by erecting a perpendicular from this point to the line $h'i'$, which represents the oblique section through the cone, a line coincident with the minor axis is obtained. It is evident that a horizontal plane $k'l'$ passed through the oblique plane $h'i'$ will contain, where it intersects at j', a line $j'm'$ equal in length to the semi-minor axis $j'n'$ of the elliptical section. Therefore, draw in $k'l'$, and from o' describe the semicircle. Erect, from j', a perpendicular to $k'l'$, intersecting the circle at m'; $j'm'$ will then be the desired length of the semi-major axis, which can be located at n'. It is now necessary to construct through the points $h'n'$ an ellipse, which can be readily accomplished accurately enough for all practical purposes by the well known method illustrated in Fig. 3, which may be described as follows:

From n', with a radius equal to $h'j'$, strike arcs at $p'P$. Insert pins at the intersections of these arcs with the major axis of the ellipse, and place around them a cord equal in length to the distance $h'i'$ plus $p'P$. Keep the cord stretched with a pencil point, and sweep in the ellipse. By applying this method in the elevation, Fig. 2, the ellipse $h'q'n'i'$ is obtained and that portion of the curve at $h'q'$ will be the curve cut of one-half the purlin. In order to find the length of the purlin and the bevel cuts for the face and edge, project the points $h'd's'r'f'g'$ on the center line of the plan,

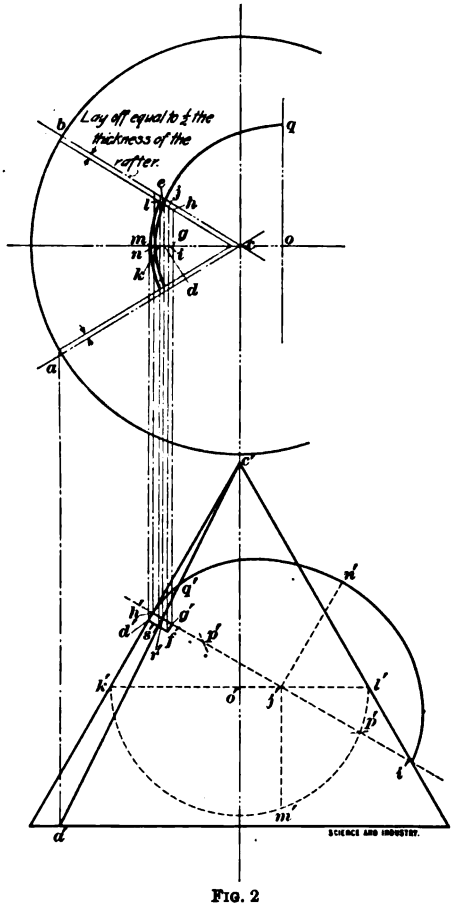

FIG. 2

and draw in kl, de, ij, and gh. The points n and e being located on the plan, and the length oq being the same as $j'n'$ in the elevation, the curve of the purlin in the plan can be

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drawn in, as shown through the points n, e, and q. In a similar manner, since the points m and l are located, the outside curve of the edge of the purlin may be drawn in the plan.

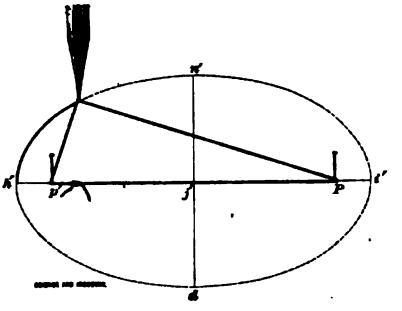

FIG. 3

It will be noticed from the plan that these lines just drawn have not been extended to the center line of the rafter, but to its face, as one-half the thickness of the rafter has been laid off from the lines $b\,c$ and $c\,a$.

The diagram having now been completed, the patterns for the face cuts and edge cuts can be laid off as designated in Fig. 4. Draw the center line $x\,y$ in this figure and lay off the thickness of the purlin as designated, and also the distances $d\,g$ and $p\,k$ equal, respectively, to $g'\,r'$ and $f'\,s'$ in the elevation, Fig. 2. The points f and m in Fig. 4 may be located by making the distances $d\,f$ and $k\,m$ equal, respectively, to $r'\,h'$ and $s'\,d'$. The lines $d\,e$, $g\,h$, $i\,j$, and $k\,l$ are equal in length to the corresponding lines shown in the plan, Fig. 2. The points e, h, j, l being thus obtained, the lines may be drawn in as shown.

The curve of the rafter, as previously explained, is an ellipse, but that portion of it adjacent to h', in the elevation, Fig. 2, is so nearly an arc of a circle that for all practical purposes such a curve may be used for the purlin. Having, therefore, in Fig. 4, the points n, f, and e, and l, m, and o, all that is necessary to do, in order to obtain the curved face cuts of the purlin, is to pass a circle through these points. Thus the simple geometrical problem of drawing a circle through three points not in a straight line can readily be done by setting the compass at n and f and m and l and drawing intersecting arcs with radii equal in length to somewhat more than one-half the distance between $n\,f$ or $m\,l$. Through the points of intersection of these arcs, extend lines that will cut the center line $x\,y$ of the figure. With the point of the compass placed at these intersections, which are designated as c' and c, Fig. 4, and with radii equal to $c'\,f$ and $c\,m$, describe the arcs $n\,f\,e$ and $o\,m\,l$. The left-hand pattern will then be the upper face of the purlin, while the right-hand pattern is that of the lower face. The bevels show the face and edge end cuts.

This may seem like a lengthy explanation for a simple problem, though it would probably take considerably less time to lay it out than to read the article. So many of these problems, however, when they drift into articles, are difficult to understand because the explanation or reason of each step has

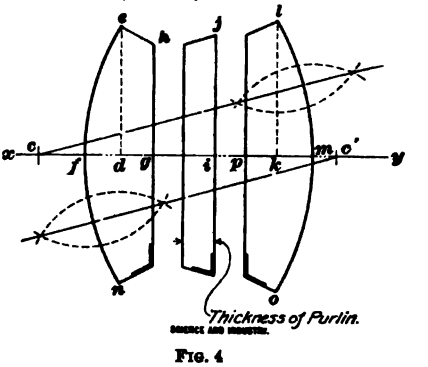

FIG. 4

been omitted, and it was with the end in view of making clear what each line and step signified that compelled the writer to offer this somewhat prolonged explanation.

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WIRING A HALF-TIMBERED COTTAGE*

Thomas H. Cooper

CONCEALED KNOB AND TUBE WORK—THE NUMBER OF LIGHTS REQUIRED—LAYING OUT THE MAINS—BRANCH CIRCUITS—HINTS FOR THE WORK

TO WIRE the cottage we will have to assume that the frame is completed and closed in, and that all floorbeams and partition studdings are in place but have not been lathed or plastered. This should be the condition of the building when the electrical work commences. We will also assume that we have been furnished with the floor and elevation plans that have been used so far in the construction of the building, but that no specifications have been written for our work, and in fact no thought has been given to the important subject of lighting with the exception of the outlets marked —○— for chandeliers and —○— for side brackets. We find on consultation with the architect and the owner that the positions of these fixtures are not arbitrary; the directions of the former are: "Use your own judgment, but do not cut the floorbeams and studding to pieces"; those of the latter are: "You know better than I do what I want—give me plenty of light conveniently controlled, and a safe job." Besides these assumptions, it will be understood that no gas-fitting has been done in the building.

The first thing to do under these conditions is to ascertain the total number of 16-candlepower lights that will be needed, so that the size of the main conductors may be determined; the next thing to decide is whether to use a 2- or a 3-wire service. In order to meet the first requirement we proceed to the cellar, the plan of which is shown in Fig. 1, and decide to place 1 light in front of the meters, 1 in front of the furnace, 1 in the center of the remaining space on this side of the cellar, and 1 on the opposite side at the foot of the stairs, 1 in front of the coal bin, 1 over the laundry tubs, and 1 in the center of the laundry—a total of 7.

For the first floor, the plan of which is shown in Fig. 2, we will use a center chandelier of 6 lights and 1 two-light bracket on each side of the space where the piano will be placed, a total of 10 lights; 1 four-light chandelier and 1 two-light bracket near the buffet in the dining room, a total of 6; 1 two-light chandelier in the hall; 1 one-light lantern on the veranda; 1 three-light chandelier and 2 one-light side brackets in the kitchen, one over the range and one over the sink; 1 one-light side bracket in the pantry, 1 one-light side bracket in the bicycle room, and 1 one-light bracket at the head of the cellar stairs, a total of 11—and a grand total of 27 for the first floor.

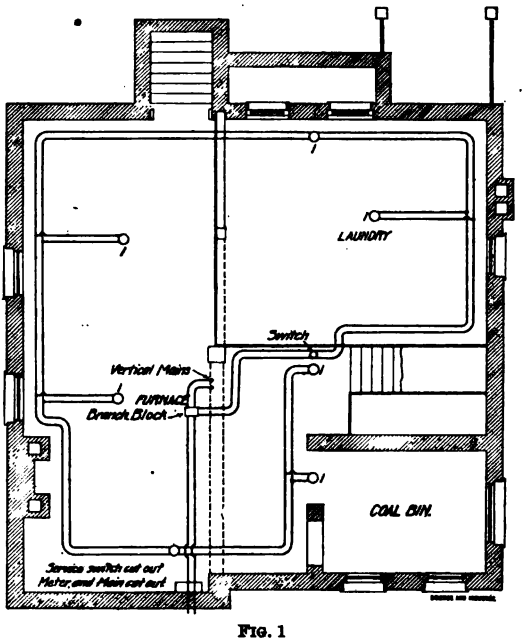

FIG. 1

For the second floor, the plan of which

*A description of the plumbing for the half-timbered cottage described in the August, September, and October, 1899, numbers of "The Building Trades Magazine" was given in the January, 1900, number of SCIENCE AND INDUSTRY. We have been requested by some of our readers to give a description of the wiring for this cottage, and publish herewith the first article, by Mr. Thomas H. Cooper, showing how to wire the building using the knob and tube system. We hope to publish an article later showing how to wire the building using conduit.

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is shown in Fig. 3, we will use 1 two-light chandelier and 2 one-light side brackets in each of the three bedrooms, one over the dresser and one over the wash stand; 1 one-light pendant in the bathroom; 1 two-light pendant in the hall; 1 side bracket in the linen closet; and 1 side bracket at the head of the stairs—a total of 17 lights for this floor.

To recapitulate, the total number of lights required on all floors is $7 + 27 + 17 = 51$ 16-candlepower lights, and the mains to feed this number of lights must carry 25½ amperes. By consulting the table of carrying capacities of wires we find that No. 8 rubber-covered wire will safely carry 33 amperes, which will give us ample allowance for drop of voltage and for adding several lights in the future.

This cottage will be built in many different places and wired for both 2- and 3-wire service and for alternating and for direct current, but we will assume for the sake of simplicity that we are wiring it for a 2-wire 110-volt direct-current service, and will explain the changes necessary to alter to the other systems. For the 3-wire Edison service the mains would be three No. 12 wires; for an alternating current of 50 or 52 volts the mains and branches would be materially increased in cross-section, and would have to be about No. 5 B. & S., because they would have to carry 51 amperes; for an alternating current of from 100 to 110 volts the conditions are the same as for direct current of 110 volts, as to sizes and work of this class. This would not hold, however, for work done in iron conduit.

The service from the street lines or conduits will, in all probability, enter the building at the same place where the gas and water supply pipes do, and at this point the supply company will place a fuse block, main plug-switch, and the meter. A two-wire main-line cut-out is set on the supply side of the meter, which is thus protected on both sides, and by removing the plug from the switch all current is cut off from the house. The mains are carried from the cut-out to a point directly under the partition separating the hall and parlor from the dining room and through this partition to the second-floor cut-out cabinet. To do this two holes, one 12 inches from the center girder and the other 8 inches from the first, are bored through each floorbeam in the cellar from the front of the house to the partition through which the lines rise, and these holes are bushed their entire length with porcelain tubes, through which the wires are drawn. Take a stud in the partitions for each line, and on this set knobs every 4 feet. On the first floor, set flush with the wall, install an asbestos-lined box of sufficient size to carry 2 two-wire double-branch cut-outs; the mains enter this box through the bottom, connect to each cut-out, and leave at the top through porcelain tubes. Carry the mains to the second floor in the same manner; here they enter a second cabinet containing 1 two-wire double-branch cut-out, in which they end. At the point in the cellar ceiling

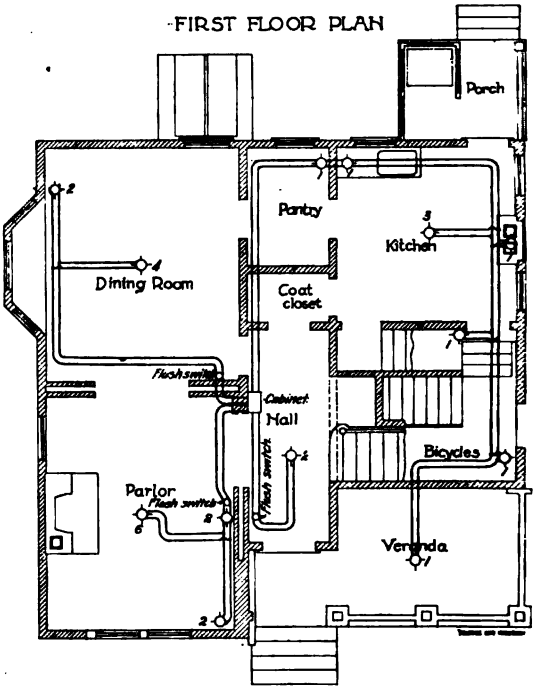

FIG. 2

where the mains become risers, set another cabinet to carry 1 two-wire single-branch cut-out for the cellar circuit. This circuit can be run in the same manner as the mains; make a complete circuit of the cellar, with taps to each outlet, or, what is more desirable, carry the branch over to the foot of the stairs and place a switch there to control the whole cellar, so that light may be turned on before entering.

From the cut-out cabinet for the first floor run a circuit to a flush switch set in the trim

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at the side of the folding doors, and from this to the center outlet and the two side brackets in the parlor; run a second circuit to a flush switch set in the trim at the side

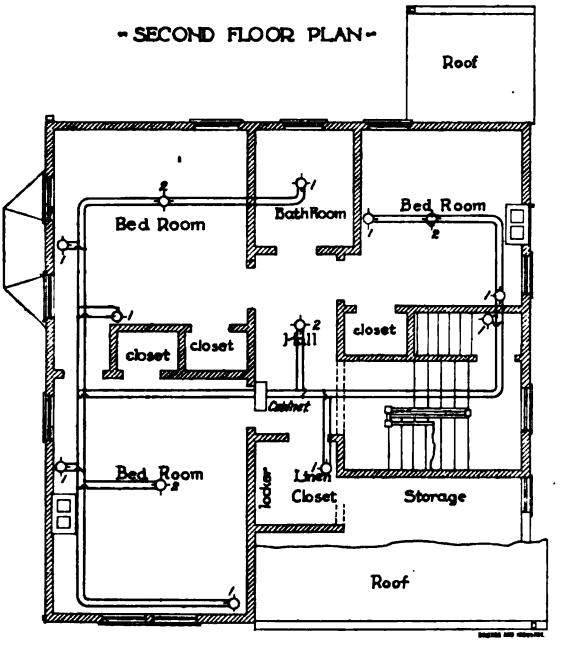

FIG. 3

of the door entering from the hall to the dining room, and from there to the center outlet and bracket outlet; run the third circuit to a flush switch set in the trim in the hall, at the side of the folding doors, and from there to the hall outlet; carry the fourth circuit to the rear of the house, cross over to the right-hand wall and back in a straight line to the veranda outlet, taking taps for the pantry, kitchen, head of stairs, and bicycle room.

These branches are all No. 14 rubber-covered wire, and are to be run on separate beams when running in the direction of the beams, and when crossing them they are to be kept 10 inches apart; on approaching the switches and side outlets take separate studs; when passing through a beam and making a sharp turn, set knobs unless the tube has a head sufficient to keep the wire ½ inch from the beam.

The second floor we divide into circuits without switches, using key sockets to control the lights as may be desired. No. 1 circuit takes the lights on the left-hand side of the floor and the bathroom light, carrying 9 lights in all, while the No. 2 circuit carries 8 lights.

Only the ordinary kit of tools will be required for this work, with the exception of a boring tool. A knuckle joint can be used to get through the beams, but a special tool is made for this class of work, and in the hands of an efficient workman this tool soon pays for itself. No. 4 porcelain knobs with ties can be used for the entire job, but G. E. separable knobs or security knobs are much better, as they save time, make a neater job, and do not injure the insulation of the wire. A regular curved outlet tube is used for each wire, and this is securely fastened to the gas outlet with tape and allowed to extend about half an inch through the plaster, as shown in Fig. 4.

When completed, this work, if neatly and securely done, should test at least a megohm resistance between the conductors and the earth. Where the wires cross gas pipe or any metal, use a porcelain tube and tape it to the wire so that it will stay in its place, as shown in Fig. 5. Lay out the hole lines on the faces of the beams with a chalk line, and bore the holes straight—it does not take any longer and looks better.

The plans of this house provide for two finished rooms on the third floor, but to wire these it will not be necessary to carry the mains any farther than the cabinet on the second floor. Install an additional two-wire single-branch cut-out, and take the branch

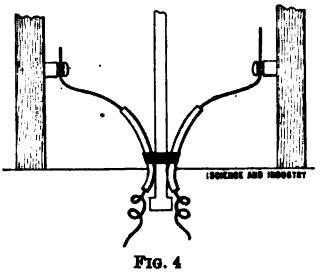

FIG. 4

wires up through the partition to the ceiling and leave two outlets, one in each room in the center of the ceiling or on the side wall. This will not increase the cost over ten dollars. It will be seen by referring to Figs. 1, 2, and 3 that the circuits might be laid out in such a manner as to shorten the

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wires, but it is not wise to save in one respect and lose in another. By following the plans laid out we do not weaken the beams, as we bore the holes close to either the side walls or the center girder, and by taking the taps between beams we save boring, and since the items of strength and labor are more important than material, the balance is largely in favor of this plan.

The cost of wiring this building will vary according to the locality, but should be from $75 to $100. The materials required are: About 1,000 feet of No. 14 rubber-covered

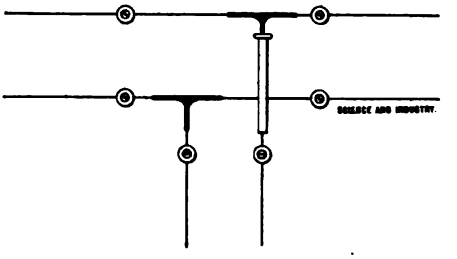

FIG. 5

wire, 75 feet of No. 8 rubber-covered wire, 350 4-inch tubes, 250 knobs, 4 flush switches, 3 two-wire double-branch cut-outs, 1 two-wire single-branch cut-out, 25 10-inch tubes, 2 wall cabinets, and screws, tape, solder, etc. The installation will require about 6 days' labor of a man and helper. The fixtures will be combination, with insulating joints and Edison lined key sockets.

A few hints in regard to doing the work may not be amiss. Bore the holes in the center of the beams, where other mechanics will not drive nails through them and thus break the tubes and cut the wires. Solder all joints well and tape them thoroughly. Do not nick the wire when removing insulation. Use no broken tubes. Pull the wires tight and do not be afraid to use knobs. As the gas-fitting has not been done, leave the outlet wires until gas drops are completed, and then finish as shown in Fig. 4. The switch outlets are left until the trim is in, when they are drawn through the holes left for the switches. The wires are covered with circular loom from the last knob up to the switch. Connect and set the switch.

This is the cheapest and a safe way to wire the cottage, but it has the disadvantage that the conductors are permanently fastened and cannot be drawn.

In another article we will show how to wire this cottage with iron conduit and panel boards, a more costly but better job. The question of bell annunciator and burglar alarms will also be treated later on.

COLUMBIA UNIVERSITY, NEW YORK

SCHOOL OF ARCHITECTURE

AFTER a student has been initiated into the inner circle surrounding art workers, and he has advanced sufficiently to appreciate that theory and practice are indispensable to worthy products, he will realize the existence of a mental atmosphere that was hitherto unknown to him. What otherwise appeared as abstractions to him, he will see hidden behind every inert mass, and the spirit of the master will converse with him when he analyzes the creations of the master mind. No city on the globe presents such varied problems of building construction and architectural treatment as does the Empire City of the Empire State. It is thus fit and proper that Columbia University should number among her schools of instruction that of Architecture, so that her students can labor among surroundings that are every-day inspirations.

The School of Architecture was founded in the year 1881, through the generosity of Mr. F. A. Schermerhorn, under the direction of Professor William R. Ware. The four-year course of study includes history, drawing and design, architectural engineering, building construction, specifications, etc. during the first three years, while the last year is devoted to independent work along post-graduate lines. The university courses are offered to graduates of the four-year course, and represent advanced study in history and design or construction and practice. Special courses are given to applicants who have had three or four years' practical experience as draftsmen in offices.

Any one desiring detailed information pertaining to the courses in this great and progressive educational institution, can obtain a copy of "The University Quarterly" by addressing the Bursar of Columbia University, New York.

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PLAN FOR DISTRIBUTING INK TO THE EMPLOYES OF A LARGE INSTITUTION

One of Them

I AM one of about a thousand employes in a large institution where most of us have two or three ink wells in constant service, using principally black, copying, and red ink. The buildings we occupy are of a very fine character, and everything must be kept scrupulously neat and clean. Not even a drop of ink must be spilled on the floor or spattered on the walls, desks, or furnishings, for our institution is one of the "sights" of the town, and many visitors "take it in." We formerly bought our ink in quart bottles having patent stoppers with two holes, as shown in Fig. 1. Each employe was expected to fill his own ink wells. This arrangement did not work well, for the bottles occasionally got upset, and in one or two instances slipped from the hands and fell on the floor, causing ink stains that will last a lifetime; and, besides the risk of disfigurement of property by such little accidents, too much time was spent in filling ink wells. Then the question arose as to how these ink wells could be quickly filled without spilling a drop. Nothing could be found on the market to "fill the bill," so one of our men was asked to exercise his ingenuity in devising something that would accomplish the object. After a great deal of hard thinking and not a little experimenting, he finally completed an arrangement that operates on the principle of a pneumatic pump, as shown in Fig. 2. The corks of our old quart bottles were thrown away and a combination stopper and pump used instead. A rubber bulb 1¾ inches in diameter is attached to the stopper, and, when this bulb is pressed, air forces ink up the tube *b* and ejects it from a nozzle *c* into the ink wells. A ⅛-inch hole is made in the top of the bulb to let in air the moment the thumb is removed from it. The tube *b* is made of rubber and extends to the lowest part of the bottle, from which it draws the ink supply. One of the best features of the apparatus is that the ink never drops from the nozzle, for the moment the hand is removed the ink in the nozzle and tube drains back to the bottle, air being sucked in through the nozzle to take its place. There is nothing imaginary about this arrangement, for we have had a large number of them in constant use since October of last year, and they have never given us trouble, except when some member of the janitor's force failed to push the stopper down air-tight after filling a bottle.

FIG. 1

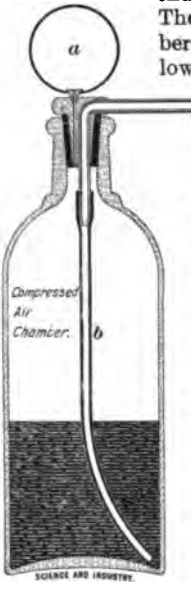

FIG. 2

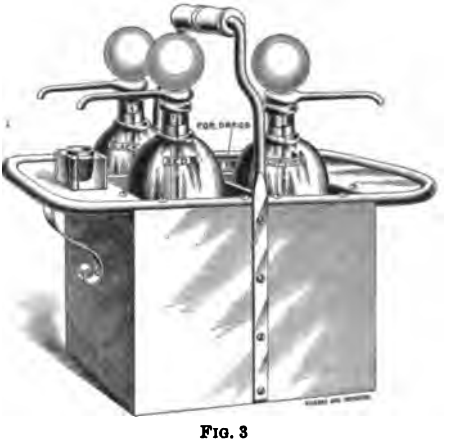

FIG. 3

In order to prevent the ink bottles from

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falling, and to facilitate distribution and keep the bottles together in a safe place, we had a number of polished mahogany carriers made that would hold a set of three bottles and a small dreg dish, which is nothing but a good-sized beer glass. The box is divided into four spaces by two cross partitions of ⅜-inch wood, as shown in Fig. 3. A brass shelf is arranged at each end to support ink wells while they are being filled; the whole upper part is bound with ½-inch split brass tubing, and the handle is also made of the same material. All the brass work is buffed and lacquered and the mahogany polished, so it will readily be seen that the entire arrangement is a thing of beauty as well as of utility.

Fig. 4 shows a young lady filling an ink well. She simply places the well under the nozzle of the bottle that is labeled with the kind of ink she wants, and then presses the bulb once and the job is done. She does not handle the big bottles at all. We now buy our ink in kegs, which is cheaper.

The janitors see that the cases are filled every evening, and office boys are detailed

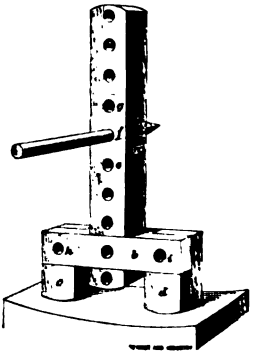
FIG. 4

to go all over the buildings every morning and fill all ink wells that need replenishing, and not a drop is spilled. The dregs or sediment in nearly empty wells is poured into the dreg glasses, and is then taken care of by the janitors.

THE NOVEL SCRIBER

E. L. Spiller, Island Pond, Vt.

THE following description and sketch shows a handy tool for scribing flooring about curved baseboards, and it will also be found useful in all curved and straight work. The accompanying figure shows the scriber in position ready for use. Its construction is clearly shown by the sketch. The blade *a* is about 6 inches long and ¾ in. × ¾ in. This is halved or otherwise fixed to *b*, which is of like cross-section and about 3 inches long.



The pieces *c* and *d* are firmly secured to the cross-piece *b* and are rounded at the lower ends so as to slide more easily along the surface of the outline it is desired to scribe. The holes *e*, *f*, *g*, etc. should be bored of such a size that the pencil will fit them tightly. It is necessary to make the device of some hard wood, in order to get a substantial and efficient tool. Holes for the pencil are also made at *h* and *i*, because they are sometimes even more convenient than those on the center line of the blade. I have used this tool considerably and it has proven satisfactory.

A QUICK-DRYING MARKING INK

Frank N. Blake, North Adams, Mass.

A GOOD waterproof marking ink that dries almost instantly and does not rub off, thus spoiling the appearance of the article marked and whatever comes in contact with it, may be made by taking the required amount of wood alcohol and adding enough nigrosene to give the desired depth of color, and enough unbleached shellac to prevent spreading, when applied to wood or paper. Any aniline color may be used if preferred to black. Ordinary alcohol can be used instead of wood alcohol, but it is more expensive and no better.

Keep the ink in a bottle fitted with a perforated rubber stopper, through which passes the handle of the marking brush; this keeps the brush in good condition and prevents waste and thickening by evaporation. A cork stopper should not be used, as the shellac will stick it to the bottle and tear out little pieces of cork.

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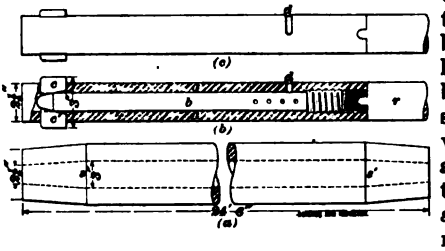
A DIFFICULT BORING JOB

Machinist

THE following description of how a difficult job of boring was accomplished may be of interest to some readers. It was required to bore a central hole through two lengths of propeller shafting, each 24 ft. 6 in. long, and the hole had to be smaller in diameter at the ends, as shown at (*a*) in the illustration. A straight hole 2¼ inches in diameter was drilled first of all through the shafts, which were revolved in a lathe, one end being held in a chuck and the other in the steadying rest. Using an ordinary lathe boring tool, the two ends of the hole were tapered the required distance. A tool made as shown in views (*b*) and (*c*) was then inserted and the hole enlarged. As shown, the tool is simply a counterbore so arranged that the cutting blades can be moved towards the axis an amount sufficient to allow the tool to be inserted, when they are expanded again to 3 inches. The counterbore is made of a hollow piece of steel *a*, slotted at one end to receive the cutters *c* and *c'*, which may be set out by means of the screw *b* having one end tapered as shown. The screw can be turned by inserting a small piece of wire through the slot *d* into one of the holes shown and turning it. The slot extends around one-quarter of the circumference, to allow this to be done. The body *a* is made of a length sufficient to bring the feed-slot outside the propeller shaft, when the cutters are at *s* if inserted from the left-hand end, or at *s'* if inserted from the right-hand end. The tool is attached to long steel rods, as *r*, and fed in by means of the tailstock while the propeller shaft is revolving. A copper tube let into the body of the tool supplies the cutting edges with oil, which is pumped in by a small pump.



EDITORIAL COMMENT

MANTELS AND FIREPLACES

AT 246 Front Street, New York, right under the shadow of the great Brooklyn bridge, flourishes a business that was established there 70 years ago by the father of the present proprietor. The present firm name is W. Jackson's Son. A glance into the store shows a large line of wood mantels, elegantly decorated brass fireplaces, grates, etc. Beautiful designs for hearthstones are wrought out in enameled tiles, and the salesroom presents the appearance of fairyland. Gas logs for natural or artificial gas, with fittings for wood fireplaces, are a large part of their business. An illustrated little booklet showing many designs of mantels and other goods will be mailed to any one who asks for "Catalogue F."

THE FRANKLIN GAS ENGINE

MANY of the amateurs who have a copy of the book "Gas Engine Construction," noted in the September number, will be glad to learn that the authors, Messrs. Parsell & Weed, 129-131 West Thirty-First Street, New York, are prepared to furnish a complete set of parts for the engine whose construction is described in their book. The various parts may be obtained either rough or finished, thus enabling the owner of the book to fit up the engine with few tools, if he so desires.

CATALOGUE OF THE FRASSE CO.

WE ARE in receipt of a booklet catalogue of The Frasse Co., 38 Courtlandt Street, New York City, which they call their "Bargain Display." The range of articles covered in it is very wide—tools, pocket cutlery, parts for models, gear wheels, files, motor bicycles, and many other things—and they advise us that every article is guaranteed as represented, and offered at a positive bargain price for a short time. This catalogue will be sent free of cost to any one who names this magazine.

GOOD JAPANESE CONTRACT

THE Japanese Government has just placed an order with The Burt Manufacturing Co., of Akron, Ohio, for the complete equipment of the imperial steel works with ten of the largest oil filters. This is the very largest and most up-to-date steel plant in Japan,

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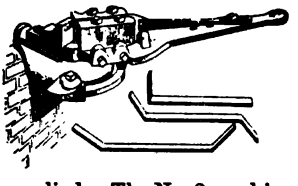
and is owned and operated by the government. The Burt Co. secured the order in competition with other American as well as English and German manufacturers.

ANGLE BENDER

THE Wallace Supply Company, 56 Fifth Avenue, Chicago, Ill., supply a very convenient machine for bending angles in round and rectangular stock by hand. The No. 1 machine will take iron or steel as large as 2 in. × ⅝ inch, or ⅝ in. round, and form any angle from 0 to 90 degrees. Light stock can be bent cold, and special dies for bending odd shapes can be supplied. The No. 2 machine will bend stock 4 in. × ½ inch on a flat bend and 1½ in. × ⅝ in. edgeways. Some samples of work done on this machine are shown in the accompanying illustration. Any further particulars will be promptly furnished on application to the makers.



WHY METAL CEILINGS?

THAT stamped metal is rapidly superseding all other materials for ceiling ornamentation and finish is little to be wondered at when its numerous advantages are considered. Not only does it offer large possibilities in architectural decoration and treatment, but it is safe, more or less fireproof, hygienic, and, best of all, moderate in first cost and economical on account of its durability.

The metallic ceiling produced by The Berger Mfg. Co., of Canton, O., appeals especially to the architect or asthetic householder on account of the harmonious and artistic effects they produce. The designs are classified, so that any architectural style may be had, and whether in the Romanesque, Renaissance, or Colonial, they all have the rich plastic effect so characteristic of clay modeling.

"Why Metal Ceilings?" is a question having several convincing answers, which are plainly set forth in a pamphlet of that title, which will be sent on request.

THE EHRSAM WATER-TUBE BOILER

J. B. EHRSAM & SONS, Enterprise, Kan., have sent us a copy of their booklet describing the Ehrsam water-tube boiler. This booklet will interest any one who has use for a boiler for generating steam for small powers. Those who demand a compact and economical self-contained boiler that can be kept clean easily and that embodies the elements of safety inherent in the water-tube type, will find the Ehrsam boiler particularly worthy of consideration. A copy of the booklet can be obtained by writing to the address of the builders.

THE STANLEY RULE AND LEVEL CO.

WE HAVE received catalogue No. 26, issued August, 1900, of the Stanley Rule and Level Company, New Britain, Conn. This catalogue is essentially a mechanics' handbook of standard rules, plumbs, and levels, iron and wooden planes, try squares, bevels, and a vast number of other miscellaneous tools that no wookworker should be without. We especially note that attention is called in the introduction to the fact that the design of many of the special tools shown originated in the suggestion of customers, and that such suggestions will always be gladly received. This frank statement is highly commendable. Attention is also called to the fact that many special tools, formerly too expensive to be found in every tool kit, are now made by improved methods, and in such quantities as to reduce the price enough to place them within reach of all. This catalogue should prove useful to any woodworker; it will be sent free of charge on application to the Company issuing it.

BOOK NOTICE

LIGHTING BY ACETYLENE. By Wm. E. Gibbs, M. E. 160 pages; second edition; revised and enlarged. D. Van Nostrand Co., New York. Price $1.50.

This book is invaluable to all who are interested in the manufacture and distribution of acetylene gas. It gives a history of its introduction and treats very fully on its generation. The electric furnaces and the many different kinds of machines used for this purpose are described and illustrated, as are also lamps of the portable type. Burners, upon which so much depends for the success of an acetylene plant, are considered in detail in a special chapter. The book also contains the underwriters' rules in regard to acetylene-gas generators, and gives a list of the United States patents up to quite a late date on calcium carbide and acetylene apparatus. Any one experimenting with calcium carbide to develop a generator, for instance, cannot afford to be without this book.

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ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*
2. *Only questions of general interest to our readers will be answered.*
3. *No questions will be answered by mail.*
4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*
5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*
6. *Reference to inquiries previously answered should give date of issue and number of question.*
7. *Questions cannot be answered in the issue of the month immediately following their receipt.*
8. *Any book not out of print and for sale by regular dealers may be ordered through the magazine.*
9. *We will not undertake to calculate windings of dynamos and motors, as this involves considerable work and is seldom justified.*

MECHANICAL

(431) Given, two second-motion hoisting engines having the same dimensions; both have 7-inch pinions, but one has a 42-inch gear while the other has a 40-inch gear. Which engine is higher geared?

T. C. S., Carrollton, Wash.

ANS.—Since the engine having the 42-inch gear will start the heavier load, some would call it the higher-geared engine. The engine with the 40-inch gear will hoist faster on the same number of revolutions, however; hence, some people would call this engine the higher-geared one. You can see that it is merely a question of the standpoint from which you look at the matter.

***

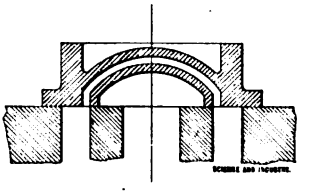
(432) (*a*) Has there ever been produced or invented a double-cylinder quarter-stroke reversible steam engine with a rotary valve or rotary cut-off? (*b*) What should be the dimensions of the cylinders to develop 4 horsepower in a double-cylinder engine when run at the highest practicable speed? (*c*) At what part of the stroke should steam be cut off?

D. H. M., Myersville, Md.

ANS.—(*a*) Reversible double engines with rotary valves have frequently been built for hoisting purposes and for rolling-mill work. (*b*) These dimensions cannot be calculated unless the boiler pressure is given. The highest practicable speed at which a double reversing engine can be run is a variable quantity that depends very largely on the care with which the rotating and reciprocating parts are balanced and on the excellence of the workmanship. Piston speeds as high as 1,500 feet per minute have been obtained in practice under very favorable conditions. For such a small engine as you desire, a piston speed of 500 feet per minute would be conservative. Then, choosing a length of stroke of 3 inches, a cut-off at quarter stroke, a boiler pressure of 50 lb., and assuming the engine to run at 1,000 revolutions per minute, the cylinder diameter is $2\frac{3}{16}$ inches. (*c*) The dimensions of the cylinders are based on a cut-off at quarter stroke.

***

(433) In the appended sketch of a slide valve is shown a supplementary port intended to return part of the steam to the opposite side of the piston just before exhaust to the atmosphere takes place. The inventor claims that he thereby saves 15% to 25% in fuel over the common slide valve. I claim that by using an ordinary slide valve with enough inside lap I can accomplish the same thing. Who is right?



J. H. C., Sheffield, Mo.

ANS.—No steam or fuel will be saved by this supplementary port. As far as your own claim is concerned, you are not likely to decrease the fuel consumption by increasing the inside lap of a common slide valve. An increase of the inside lap causes a later release and an earlier compression.

***

(434) Do you know anything in regard to wire lacing for belts? What are its advantages over ordinary lacing? How are belts laced with wire, and what kind of wire is used?

J. R., Severn Bridge, Ontario.

ANS.—Wire lacing for belts is quite extensively used in the United States. Its advantages are that a belt can be laced quicker than by any other method; the cost of the lacing is much less; the lacing is the same on both sides of the belt and even with its surface; and the belt can be connected up or disconnected in a moment. Its disadvantage is that it is impossible to lace the belt by hand; a machine specially made for this purpose must be used. The wire used is ordinary steel wire. The machine and lacing for it can be obtained from Robert Bissell, 15 North Fourth Street, Philadelphia, Pa., U. S. A.

***

(435) (*a*) What is the radius of the link arc in the Stephenson link motion? (*b*) What causes gauge glasses used on marine boilers to be eaten away on the bottom end? (*c*) I have seen a valve gear fitted to a marine engine in which no eccentrics are used. The valve gear is connected to the center of the connecting rods, and the motion is transmitted through suspended levers to the valve stem. Kindly give the name of the valve gear.

C. A. A., Manila, Philippine Islands.

ANS.—(*a*) The radius of the link is generally taken equal to the distance from the center of the eccentric to the center of the link block when in full gear, or what is the same thing, the distance from the center of the shaft to the middle position of the center of the link block in full gear. When thus made, the valve will move *very nearly* equally on both sides of a fixed point. (*b*) While we know from personal observation that this is often the case, we are unable to give a satisfactory explanation of the phenomenon. (*c*) Judging from the limited description given, we are inclined to think that the engine

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is fitted with Joy's patent valve gear. Without seeing a sketch of it we cannot state so definitely, however.

***

(436) (*a*) Please explain the hydrocarbon system for propelling automobiles. (*b*) What chemicals are used in C. D. Gibson's carbonic-acid system? (*c*) How can I make a good carbureter for a ½-horsepower gasoline engine?

J. E. W., Wheeling, W. Va.

ANS.—(*a*) The term hydrocarbon used in connection with methods of driving automobiles refers to the character of the fuel used in the motor. A hydrocarbon motor is one that uses a hydrocarbon vapor as fuel in the same manner that gas is used in a gas engine. The particular vapor most used in this country is gasoline; hence, an automobile using the hydrocarbon system is generally one propelled by a gasoline engine. (*b*) In the carbonic-acid system, liquid carbonic-acid gas is stored in tanks and power is obtained from the gas formed by the evaporation of this liquid, either from the heat obtained from the surrounding air or from any other convenient source. The gas is used in an engine similar to an ordinary steam engine. (*c*) We cannot devote as much space in these columns as would be required for a description of a carbureter. Most of the successful carbureters are patented, and much more satisfactory results can be obtained from one of these than from any simple home-made device.

***

(437) (*a*) What is the temperature of steam under 75 lb. boiler pressure? (*b*) What is the difference between the temperature of the inner surface and the temperature of the outer surface of a 1-inch pipe filled with steam, assuming that the pipe is surrounded by air at a temperature of 65° F.? (*c*) What is the loss of heat in passing through an iron pipe from the steam to the air surrounding the pipe? (*d*) In a drawing room heated by steam pipes and ventilated by a fan, is it better to blow air in between the steam pipes or to suck it out of the building from the ceiling?

C. W. G., St. Hyacinth, Can.

ANS.—(*a*) 320° F. (*b*) The difference in the temperature is so slight that it is considered by heating engineers to be inappreciable. Thus, it is usually considered that the temperature of the outer surface of a pipe containing steam at 75 lb. pressure is about 320°. This is due to the fact that the air takes heat from the pipe very slightly, compared with the capacity of the pipe to conduct the heat from its inner to its outer surface. (*c*) There is no loss. (*d*) This depends considerably on the construction of the apparatus. Ordinarily speaking, either plan will give good results. Presumably the suction method is favored more than the other.

***

(438) (*a*) Is it absolutely necessary to use the by-pass valve of a Vauclain compound locomotive when starting—either as a lone engine or with a train? (*b*) Is there any such iron as Russian iron, or is it simply ordinary iron put through some process to give it a gloss? Does the genuine Russian iron ever get rusty? (*c*) Are the steam and air cylinders of a Westinghouse 9½-inch pump of the same diameter? (*d*) Which gives off the greatest heat, alcohol or gasoline? (*e*) How does an excess of air supplied to the firebox cause loss of heat, and how is such a condition detected? Does the formation of carbon monoxide during combustion result in a loss of heat?

R. F., New Orleans, La.

ANS.—(*a*) The starting valve, which is a by-pass valve, is operated by the same lever that works the cylinder cocks, the connections being so made that when the lever is in its middle (upright) position the valve is closed and steam only reaches the low-pressure cylinder, the engine working as a compound. When the lever is moved to its front position, the starting valve will be wide open, thus allowing live steam to pass direct into the low-pressure cylinder, the cylinder cocks on both high- and low-pressure cylinders opening simultaneously. With the lever in this position, the engine will work as a simple, or single-expansion, engine. If the lever is moved to its rear position, the cylinder cocks will be closed and steam will reach the low-pressure cylinder; that is, the engine will work compound. As regards using this valve: When starting after having stood for some time, one naturally wants to open the cylinder cocks, regardless of the weight of the train, and in doing so the starting valve is moved, which allows live steam to go direct to the low-pressure cylinder, thus working the engine simple. But, waiving the item of clearing the cylinders of condensation, you need only work the engine simple when starting with a heavy train or when likely to get stalled on a heavy grade. (*b*) The genuine thing is actually made in Russia, although the term is applied to imitations of it wherever made. For a long time it was not known just what processes the Russian manufacturers put this iron through, but it is now pretty well known, having been observed by travelers. Briefly told, the process consists in producing a combined silicate and oxide of iron on the surface of the sheets, which are moistened with wood ashes and passed while hot through polished steel rollers, the gloss being produced in this way and by hammering and rolling, not, like enamel, being put on as a separate substance. In short, close observers have concluded that the Russians obtain their results by using a very good and pure iron in the first place, and by observing great cleanliness, care, and skill in the operation. "Russian iron" is produced in many countries. Ordinary sheets may be made to resemble the genuine article by dropping them while hot into a thick mixture of chalk, porcelain clay, and graphite; after which they are dried and annealed, put in sulphuric acid and water to get the scale off, then immersed in potash and water, and finally in clear water, and afterwards smoked in an oven heated with wood; as the heat increases, the soot is burned off and a carburet is formed on the surface. The sheets are then well hammered and rolled in polished rolls. *Planished* iron, the term applied to the above iron in general, will not rust nearly so quickly as ordinary sheets that are unprotected by the scale that is formed on the former. (*c*) The two cylinders of the 9½-inch air pump are of the same size when new. (*d*) Gasoline. (*e*) If the volume of air admitted to the fire is too great for the requirements, the temperature in the firebox will fall; if the drop in temperature is so great that the combustion of the gases does not take place properly, smoke may result, owing to the particles of carbon disengaging themselves from the gases and passing off unburned. The loss in temperature will necessarily also cause a drop in the steam pressure, as the quantity of heat passing through the sheets to the water is at once diminished. When the carbon burns only to carbon monoxide instead of to carbon dioxide, the combustion is less perfect, and smoke will appear, fuel being thus wasted, with the corollary of diminished steaming efficiency.

***

(439) Where can I obtain a small water motor suitable for driving a ¼ H. P. lathe?

C. E. B., West Oakland, Cal.

ANS.—Send to any of the following parties for catalogues and price lists: The Pelton Water Wheel Co., 121 Main St., San Francisco, Cal.; James Leffel & Co., Springfield, Ohio; S. Morgan Smith Company, York, Pa.

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(440) Please give the derivation of the formula $Q = \frac{13{,}750\ W l}{P L}$. In this formula Q = steam used per indicated horsepower per hour; l = the length of a line between a point on the expansion line, just before release, and a point on the compression curve at the same height above the vacuum as the point on the expansion curve; L = length of indicator card; P = M. E. P. of the steam on the piston; W = weight of a cubic foot of steam whose absolute pressure is represented by the height of the line l above the vacuum line. F. H. C., New York, N. Y.

ANS.—Imagine that you have an indicator diagram before you. Draw perpendiculars to the atmosphere line tangent to the card at each end. The length of the atmosphere line between these two perpendiculars is the length L of the card. Next produce the line l beyond the compression curve until it intersects the perpendicular at that end of the card. Mark this point a; also mark the point where l intersects the compression curve b and where it intersects the expansion curve c. Since L represents, to some scale, the volume of the cylinder, the line ac represents to the same scale the volume swept through by the piston from the beginning of the stroke up to the point c. This volume also represents the total volume of steam in the cylinder at an absolute pressure indicated by the height of the line l above vacuum. By referring to the steam tables the weight W of a cubic foot of steam at this pressure is found. Multiplying the volume of the steam in cubic feet by its weight per cubic foot, the total weight of steam in the cylinder is determined. Of this quantity of steam that represented by the produced portion ab of the line l remains in the cylinder on account of the closing of the exhaust port. Consequently, the steam used or exhausted during one stroke is represented by the length bc of the line l. We will, as defined above, designate the length of this part of the line by the letter l. If we designate the volume of the cylinder in cubic feet by V, a little consideration will show that the volume of steam used per stroke is $\frac{l}{L} \times V$ cu. ft. The weight of steam used per stroke will therefore be $\frac{l}{L} \times V \times W$ pounds. Letting N represent the number of strokes per minute, we will have for the weight of steam used in one hour, $\frac{l}{L} \times V \times W \times 60\ N$ pounds. The horsepower of an engine is given by the formula $\frac{P\ L'\ A\ N}{33{,}000}$, where P = M. E. P. of the steam; L' = length of stroke in feet; A = area of piston in square inches; N = number of strokes per minute. Let A' be the area of piston in sq. ft. Then, $A = 144\ A'$. Substituting in the formula for the horsepower for A its equivalent $144\ A'$, this formula becomes $\frac{144\ P\ L'\ A'\ N}{33{,}000}$. But $L'\ A'$ = volume of cylinder in cubic feet = V. Hence, horsepower = $\frac{144\ P\ V N}{33{,}000}$. Now we have found the steam used by the engine in one hour. But we want to find the steam used in one hour *for one horsepower*. Hence, we divide the steam used per hour by the horsepower; thus:

$$Q = \frac{l}{L} \times V \times W \times 60\ N \div \frac{144\ P\ V N}{33{,}000}$$

$$= \frac{\frac{60 \times l \times V \times W \times N}{L}}{\frac{144 \times P \times V \times N}{33{,}000}} = \frac{60 \times 33{,}000}{144} \times \frac{l \times V \times W \times N}{P \times L \times V \times N}$$

Both N and V cancel out, and we have

$$Q = \frac{60 \times 33{,}000}{144} \times \frac{l \times W}{P \times L} = \frac{13{,}750\ l\ W}{P\ L}.$$

(441) (*a*) How can a bicycle be kept in good running condition; that is, what care should the bearing parts and chain receive? (*b*) Is vaseline a good article to place in bearing parts? If so, how should it be put in and how often renewed? Is any oiling necessary if such is done? (*c*) Can you advise anything to rub on the nickeled parts of a bicycle to keep them from rusting? (*d*) Kindly explain a simple method of nickelplating, describing the process and chemicals used, together with the proper proportions. E. J. S., Brooklyn, N. Y.

ANS.—(*a* and *b*) Keep the bearings and chain clean and well lubricated. It is a good plan to clean the bearings occasionally, using benzine to wash the dirt out. The chain should be taken off and allowed to soak for some time in a shallow dish with enough kerosene or benzine to cover it. The links should each be worked back and forth in the fingers, to make sure that none of them have become stiff or rusted fast. After the chain has been replaced, it should be well treated with graphite chain lubricant. The bearings should be oiled with a good quality of oil, which you should be able to obtain from any bicycle dealer. Pure sperm oil is as good as any. Vaseline is put in the bearings of wheels when they are sent out by the makers, but it is not generally used for lubricating them. (*c*) A good thing to use for this purpose is what is known as "Three in One"; you can obtain it from any dealer in bicycle supplies. (*d*) There is no simple way of doing nickelplating that we know of. Electroplating is the only way in which it can be done, and if any parts of your wheel need plating you will save both time and money by having it done by a regular plating establishment. We have not the space here to go into the details of electroplating, but if you wish information regarding it we can refer you to a book entitled "Modern Electroplating," by J. H. Van Horne, which can be had from The Technical Supply Co., Scranton, Pa.

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(442) What horsepower is required to raise 75,000 gal. of water 100 ft. in 90 min.? Please give formula for working it. A. C. C., Circleville, O.

ANS.—The following formula gives the approximate horsepower required to discharge a certain number of gallons of water per minute with the given lift: $H = .00088\ G\ h$, in which H is the required horsepower; G, the number of gallons raised per minute; and h, the vertical lift in feet. 75,000 gallons of water raised in 90 minutes is equal to 833⅓ gallons per minute. Substitute this for G in the formula, and 100 for h. The result is $.00088 \times 833\frac{1}{3} \times 100 = 31.67$, which is approximately the required horsepower. This makes an allowance of about 50 per cent. for slip, for friction in the engine, pump, pipes, etc.

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(443) Kindly explain the process of brazing brass, and state where a suitable flux and spelter can be obtained. G. C. W., Conesus, N. Y.

ANS.—The process of brazing brass is as follows: Thoroughly file or clean the parts to be brazed; place them on a piece of charcoal and secure them in position, being sure that the joint to be brazed is thoroughly cleaned inside and fitted close; then sprinkle same with pulverized borax that has been previously dampened with water. Lay some pieces of spelter in this borax and then heat the joint with a blowpipe flame composed of ordinary gas and air. When the joint becames heated the borax will curl up, so to speak, then melt, and run into the joint. The pieces of spelter that remain on top of the joint become red hot and soon melt, when they follow the borax into the joint. After the spelter has "run," remove the blowpipe. Do not disturb the joint until it is cold. The flux is preferably composed of calcined pulverized borax. You can get it at any drug

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store. The spelter can be purchased at a brass foundry or from any metal merchant; or you can make it yourself by cutting up brass wire in short pieces about ¼ in. long.

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(444) What would be the thickness of the walls of a lead pipe of 3″ bore, to safely sustain a pressure of 60 pounds of cold water per square inch? The pressure is a steady one, due to a head of water.

T. C. H., Baltimore, Md.

ANS.—The pressure on a length of 1 inch is $1 \times 8 \times 60 = 180$ lb. The tensile resistance of the section is $1 \times 2t \times f$, where t is the thickness of pipe and f the working tensile stress in pounds per square inch. We should not care to allow much more than about 175 lb. for f in the case of a metal like lead, which is known to yield under a comparatively slight stress constantly maintained. Equating the above two products, we have $2t \times 175 = 180$; whence $t = \frac{180}{350} = \frac{1}{2}$ inch, say. We have had no experience with lead pipe of this diameter carrying heavy pressures; if you think fit to adopt any other unit stress, multiply it by 2 and divide the product into 180, and the quotient will be the thickness of pipe required.

ELECTRICAL

(445) (*a*) To what resistance should bridged ring-off drops be wound for series-grounded and bridged metallic circuits that are connected together through a repeating coil wound for from 175 to 250 ohms on each side, so that both lines can ring off? The drops are for a single-cord board, so they would be used as main-line drops part of the time. (*b*) Is it possible to ring through a repeating coil? (*c*) What would be the resistance of a ground return of one mile, if perfect ground connections were made?

WM. R. S. D., Jr., Petersburg, Que.

ANS.—(*a*) We would advise using on the series-grounded side a series ring-off drop of about the same resistance as the subscribers' ringers on that side. This drop could also be used as a series main-line drop. For the bridged metallic side, use a drop wound to from 300 to 400 ohms and shunted by a condenser; connect the combination (coil and condenser) in series with the repeating coil, and in the middle of the metallic-circuit side of the coil, in order to avoid unbalancing the metallic-circuit side. It does not seem advisable to attempt to use this ring-off drop for a line drop also. You should have a few cord circuits fitted up with repeating coils and ring-off drops, and only use these cords when really necessary to use a repeating coil. Where it is possible to spare the time, it is more reliable, when repeating coils are used on an ordinary board, for the operator to listen occasionally, especially on long bridged circuits, rather than to use and depend on ring-off drops for the disconnection signal. (*b*) Yes; it is certainly possible to ring through a repeating coil, provided the coil is well made and has a good complete iron circuit. However, there has been more or less trouble ringing through repeating coils. (*c*) The resistance of the ground return depends on so many things that it is impossible to give a definite figure for it. Telegraph engineers consider a ground return poor if it is over 10 ohms, but in telephone work, where less care is generally taken in making the ground connection, it is liable to run all the way from 50 ohms up. The distance when it exceeds about ¼ a mile has very little influence on the resistance of the ground return. There is no such thing, probably, as a perfect ground connection, and practically all the resistance in the ground return is at the contact surface between the earth and the grounded plate or wire, unless the region between the two grounds is very rocky or full of coal.

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(446) (*a*) What is graphite and where can I buy it? (*b*) How is it prepared for resistance in electrical work? (*c*) I wish to make a resistance in the form of a paste that will get hard; also a piece ¾ inch wide, ¾ inch long, and ¼ inch thick that will offer a resistance of 200 ohms and carry .5 ampere. How shall I proceed to make it? Is there any book that treats on the subject?

A. H. M., Chesaning, Mich.

ANS.—(*a*) Graphite is one of the allotropic forms of carbon. The so-called lead of an ordinary lead pencil is composed almost wholly of graphite. You should be able to obtain it in the powdered form at almost any hardware store, or from dealers in machinery supplies. (*b* and *c*) Graphite used for electrical purposes is usually in the form of plates or rods. We cannot give the process of manufacture. A great deal of experimenting has been done on the manufacture of graphite resistances, and if you are in need of such we would advise you to purchase them rather than attempt to make them. The Joseph Dixon Crucible Co., of Jersey City, N. J., make these resistance rods for a number of electrical concerns, and you can, no doubt, get what you want by writing to them. There is no book that we know of on the subject.

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(447) (*a*) Can a No. 1 motor 3½ inches high be used as a generator to run one or two miniature incandescent lamps of from 1 to 3 candlepower, or to charge a storage battery? (*b*) If so, how can it be done? (*c*) Would anything else be needed in the circuit? (*d*) For an induction coil with a core 6 inches long and ¾ inch in diameter, what would be the proper size of wire for the primary coil and what for the secondary coil, and how much of each? (*e*) If the dimensions of the core given above are not correct, please give proper ones.

C. F. G., Rockingham, N. S.

ANS.—(*a*, *b*, and *c*) It is doubtful whether as small a motor as this will work satisfactorily as a generator. Keep the connections the same as when it is used as a motor if the machine is shunt-wound. Drive the armature from some outside source of power, at about the same speed that the motor was designed to run. Connect the small incandescent lamps across the terminals of the dynamo. These lamps should be of the same voltage as the E. M. F. the motor was designed to run on. If the machine generates properly, the incandescent lamps will light up. If the machine fails to generate, disconnect the field coil from the armature and connect the field coil to the terminals of a cell of closed-circuit battery. Connect the incandescent lamps across the armature brushes. Drive the armature as before, and you will probably obtain enough E. M. F. to light the lamps. The small dynamo could charge one or more cells of storage battery if the E. M. F. generated by the armature were 20 or 30 per cent. higher than the E. M. F. of the storage battery. The charging would be a rather slow process, however. (*d*) Use two layers of No. 19 wire for the primary coil and about 8 oz. of No. 38 wire for the secondary coil. (*e*) The dimensions of the coil, 6 inches by ¾ inch, are correct for a small induction coil.

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(448) How can the induction be stopped on a ground-return telephone line ¼ of a mile in length running near electric-light wires and other telephone wires?

C. E. B., West Oakland, Cal.

ANS.—The only way to stop induction on a single-line wire ground-return system is to move the line some distance away from the disturbing wires. If you cannot do this, make it a complete metallic

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system by putting up another line wire and cutting out the grounds at the ends of the line. Run the two wires parallel, and at intervals of about a hundred feet transpose the wires by crossing them. See that the wires do not touch each other at the points of crossing.

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(449) Please give a diagram of the wiring of an electric automobile. S. J. H., New York.

ANS.—A complete diagram and description of the wiring of an electric automobile would require too much space to be inserted in these columns. We expect to publish, in the near future, an article on electric automobiles, their equipment, connections, etc. In our answer to inquiry No. 283, June number of SCIENCE AND INDUSTRY, we described a diagram of controller connections for an electric automobile.

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(450) (*a*) Would it be better for a young man 19 years of age to learn some such mechanical trade as the machinist's or the electrician's or to take up its commercial side? (*b*) Which will be installed to a greater extent in the coming years, electrical or compressed-air apparatus? (*c*) Please recommend some recent books on electric-light wiring and on dynamos and motors. F. L. L., New Derry, Pa.

ANS.—(*a*) This depends on the natural inclinations of the person. There seems to be more chance for a person to achieve financial success by application to the commercial side; a thorough mechanical knowledge, however, will be a great aid. (*b*) We cannot tell what improvements may be brought out in electrical or compressed-air apparatus, but on account of the greater flexibility of the electrical system, it seems probable that electrical apparatus will be installed to the greater extent. (*c*) "Electric Wiring," by C. P. Poole, price $1.00; "Dynamo-Electric Machinery," by S. P. Thompson, price $6.00. These books may be purchased from The Technical Supply Co., Scranton, Pa.

BUILDING TRADES

(451) (*a*) Please tell me the best method to adopt in a very cold country to prevent the water from freezing in the traps of plumbing fixtures. (*b*) Supposing that the hot- and cold-water pipes in a one-story building had to be run on the ceiling, what is the best arrangement to drain them?

A. F., Fort Grant, Arizona.

ANS.—(*a* and *b*) See article "Care of Plumbing," in the September issue.

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(452) There is a 30-gallon kitchen boiler here that makes a terrible noise when the faucets are opened and water drawn at the fixtures. The waterback is of the U pattern. The circulation pipe and boiler become very hot, and there is always a good supply of hot water in the building. What is the trouble?

F. H. S., San Francisco, Cal.

ANS.—It would appear that the waterback is too large for the boiler; or, what is the same thing, the boiler is too small for the waterback. The water in the boiler appears to be heated nearly to the boiling point, at the pressure to which it is subjected. When a faucet is opened at any of the fixtures, the pressure of the water in the boiler is reduced. This allows the water to make steam in the boiler, which causes the snapping sound you hear. If a 30-gallon boiler is large enough for the building, we would suggest that you cover some of the heating surface of the waterback with soapstone, to prevent some of the heat from acting upon it; or, remove the waterback and put in a smaller one.

(453) Kindly refer me to a good practical work on groined arches and centering for same.

F. L. W., Washington, D. C.

ANS.—We are not certain what character of a book you wish. There is an excellent book giving general information, history, etc. of groined arches as employed in Gothic and Romanesque architecture. This book is entitled "Rational Building," by Viollet Le Duc, and can be had for $3.50. Should you desire a book on stereotomy, we would recommend "Warren's Stone Cutting," by S. Edward Warren, C. E. Price $2.50. Both of these books can be obtained from The Technical Supply Co., Scranton, Pa.

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(454) Will you kindly inform me whether cast iron, wrought iron, or lead pipe will be durable if completely buried in cement mortar composed of equal parts of bar sand and Portland cement?

F. C., Philadelphia.

ANS.—Pipes of these materials completely covered with cement mortar will be almost entirely free from external corrosion. When iron pipes are laid in cement mortar, however, care should be observed to see that they are thoroughly coated with some good paint before being laid, as the water contained in the cement before it has set will start an initial corrosion, and also because there is some sulphur in cement, which in the presence of moisture may produce a destructive chemical action. The paint keeps the moisture from the metal until the cement has set, when the moisture no longer exists in appreciable quantities. Leaky joints in the pipe would cause some trouble, but with good workmanship such are not likely to occur.

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(455) I would like information regarding the proper method or system of building a crown over a kiln for burning brick or tile. Should such a kiln be rated on the basis of a third, a quarter, or a half pitch, or can a rise of any height be made, say 2 ft. or 1½ ft., without injuring the stability of the crown? J. A. M., St. Thomas, Ont., Can.

ANS.—We presume that you refer to kilns having spherical or domical tops, and offer the following information accordingly. The rise of the crown on a kiln may be made any height. The nearer the crown approaches a hemisphere, the less thrust there will be on the walls. When the rise of the crown is less than one-third the span, it would be better to tie in the top of the kiln with iron or steel bands of heavy section. This should be done in *all cases* where the walls are thin and lack stability sufficient to support the thrust of the crown.

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(456) What is it that causes a crackling noise in my hot-water boiler attached to the kitchen range? The noise occurs generally when a hot fire is being used for baking purposes.

J. H. C., Hyde Park, Mass.

ANS.—The crackling noise may be due to an accumulation of mud in the bottom of the boiler, which would choke the lower circulation or feed-pipe to the waterback; or it is possible that the upper pipe between the waterback and the boiler is "sagged" so that the waterback is air-locked. An accumulation of air here would prevent circulation between the waterback and boiler, which would allow the water in the waterback to boil and produce steam, which, when expanding back into the boiler, would rapidly condense and make loud noises. It is possible, also, that your waterback is too large for the boiler, or what is the same thing, the boiler too small for the waterback. You can readily determine this latter possibility by allowing hot water to run at the kitchen sink when the snapping sounds occur.

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If this escaping of hot water stops the noise, you may safely decide that the waterback is too large. If the noises do not stop, there is a defect in the circulation between the range and the boiler due to mud, incrustation, air-lock, or something else.

MISCELLANEOUS

(457) A ¾-inch cable 200 feet long is stretched by a force of 1 ton; if the breaking strength of the cable is 5,000 pounds, what is the greatest load that can be hung from its middle point?

P. A. Y., Columbus, O.

ANS.—This problem is much more complicated than appears at first sight. The solution of it (for which, by the way, it is necessary to know the weight of the cable) involves long and tedious operations of advanced mathematics, to perform which more time is required than we can afford to devote to such matters. We are both willing and glad to answer any questions our correspondents may ask, provided they are of a practical or at least of an interesting character, and do not require an exceedingly great amount of work. But questions such as the one you ask would prove of interest to but few of our readers, and would take up the time that we think it our duty to devote to answering more important questions, on more useful and practical subjects.

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(458) I want to make a new screen for our village water supply. I would like it in double frames, so as to pull it out and clean the meshes conveniently. The water in the reservoir is 4 feet deep and the pipe is 6 in. in diameter. Please give directions.

W. H. Y., Bartlett, N. H.

ANS.—If the box you use at present for the screens is large enough, you can arrange double-frame screens by nailing two slats at the back or in front of the present screens, which will form a guide for new screens to slide in. All the screens should be made so that they can be taken out one by one. By having double screens you will be able to clean any or all of the screens without allowing water to flow into the pipe unscreened, for it will only be necessary to take out one screen at a time to clean them. By this arrangement the water will pass through double screens before it enters the pipe, when the screens are all in place. It will only flow through a single screen, however, when the screens are being cleaned. If you double-screen the box, we would suggest that you add 50% to the area of the present screen openings, to allow for an increased resistance to the flow due to the presence of the extra screens.

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(459) Please calculate or give a method of calculating the graduations on a rod that, when inserted in a horizontal cylindrical tank and withdrawn will indicate the number of gallons in the tank.

A. M., Springfield, S. D.

ANS.—See answer to inquiry No. 421 in the September issue.

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(460) (*a*) Fig. 1 is a plat of a survey having five sides; how can I determine the angles so that it will close? You will see that if it had only four sides it would form a square, with right angles, but side (3) makes an angle of 45° with side (2); also, side (4) makes an angle *n* of 90° with the prolongation of side (3). What I wish to know is how to figure the angles when one or more of them are reentrant, or when the sides run into the field of survey. (*b*) When the plat contains a reentrant angle, as the angle between the sides (3) and (4) of the figure, should the exterior angle *X* or the inner angle *n* be taken? (*c*) In Fig. 2, *A B* and *C D* are due north and south lines. What are the bearings of the intermediate lines *a b*, *c d*, etc., and how can I determine these bearings? (*d*) If one of the section lines measures 79 instead of 80 chains, what is the proportional measurement for subdividing the section? (*e*) If this is a north and south section line, what would be the bearing of the adjacent east and west section line? (*f*) How is a rope ferry constructed, and how is the steering gear arranged? (*g*) How does the current drive the boat across the river? (*h*) Please give dimensions of a ferryboat to carry four teams with loads. (*i*) Please give size of rope for a span of 1,200 feet. (*j*) How far up stream from the boat and how high above high water should the span rope be?

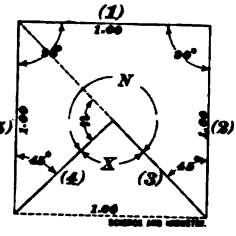

FIG. 1

J. W. M., Newcastle, Pa.

ANS.—(*a*) In order to determine whether the angular measurement closes in the plat of any survey, it is only necessary to apply the well-known principle of geometry that *the sum of the interior angles of a polygon is equal to twice as many right angles as the polygon has sides, less four right angles.* This applies to figures having any number of sides, without regard to whether any of the angles are reentrant. Thus, as the angle *n* in the figure is 90°, the angle *X* must be equal to 180 − 90 = 90°, and the angle *N* must be equal to 360 − 90 = 270°, making the sum of all the interior angles of the figure equal to 90 + 90 + 45 + 270 + 45 = 540° = 6 right angles. As the figure has five sides, the above principle gives 2 × 5 − 4 = 6 right angles. (*b*) The *interior* angle must be taken in each case. This must not be the angle between one side and the prolongation of the adjacent side, as the angle *n*, in the figure, but the entire interior angle between the two sides themselves, as the angle *N*. In the case of a reentrant angle, the interior angle *N* will always exceed 180° by the amount of the angle *n* and in making the survey it may sometimes be more convenient to measure the exterior angle *X* and subtract it from 360°, or to measure the angle *n* and add it to 180°. (*c*) We infer that your sketch, Fig. 2, is intended to represent the subdivisions of a township, the lines *A B* and *C D* being township or range lines, and the lines *a b*, *c d*, etc. being section lines. This being the case, it should be understood clearly that in making the original surveys the intention is to run all these lines due north from the base line and from the standard parallels. Owing to the spherical form of the earth, these meridian lines converge toward the pole, that is, approach each other as they extend northward, so that the distances *B b*, *b d*, etc. will be less than the corresponding distances *A a*, *a c*, etc. The convergency of the meridians varies as the sine of the latitude, that is, in any latitude the convergency of the meridians for one degree of longitude, expressed in decimals of a degree, is equal to the sine of the latitude. As any deviation from due north in the

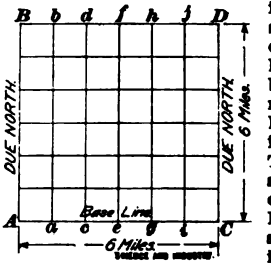

FIG. 2

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bearings of any of the lines referred to is the result of inaccuracies of instrumental measurements, it is impossible to apply any theory to the determination of the bearings of the lines that do not bear due north. (*d*) When the section line between two adjacent corners of the original survey are found to actually measure more or less than its recorded measurement, then in subdividing the section the measurements along that line are taken in the same proportion. Thus, suppose the distance between a section corner and the adjacent quarter-section corner is found to be 39.50 chains, instead of 40 chains; this would be $\frac{79}{80}$ of the recorded distance. Then, in subdividing the adjacent quarter-sections, *all measurements along the section line between them* would be $\frac{79}{80}$ of their theoretical or recorded values as determined by considering this distance to have its recorded value of 40 chains. (*e*) Where the length of a north and south section line is just 80 chains, and the length of the north and south section line next east or west of it is more or less than 80 chains, the excess or deficiency of the latter line, in chains, divided by 80, will be, approximately and very closely, the tangent of the angle of the variation of the intervening east and west section line from due east and west, provided the east and west section line at the opposite ends of the north and south section lines bears truly east and west. (*f*) In a rope ferry or cable ferry, the ferryboat is guided across the stream and held in position against the current by means of a rope or cable stretched across the stream at approximately right angles to the current and under sufficient initial tension to prevent excessive sag or deflection from the pull of the boat under the force of the current. By means of a smaller rope connected to and operated by a windlass, the ferryboat is connected with a pulley that travels along the rope or cable. This rope is wound a few times around the windlass, which is usually near the center of the ferryboat, lengthwise, and the two ends, passing under pulleys at opposite ends of the ferryboat, are both attached to the traveling pulley which travels along the cable. Thus, by operating the windlass, either end of the boat can be drawn toward the cable, the opposite end falling away (down stream) by the same operation. The ferryboat is an ordinary flat-bottom boat or scow, having vertical sides and both ends alike, with a permanent railing along each side and a movable railing across each end. (*g*) In order for the boat to be propelled across the stream by the current, it is only necessary to draw the forward end toward the cable by a few turns of the windlass, allowing the stern to fall away from the cable at the same time. The forward end of the boat will then point somewhat up stream, and in this position the boat will be driven across the river by the force of the current, in substantially the same manner as a propeller steamboat is driven by its screw wheel. (*h*) The dimensions of a ferryboat necessary to carry a given load will depend upon its draft, that is, the depth to which it is to sink into the water, which in most cases must be small. In order to estimate the load that a boat of given dimensions will carry, including its own weight, multiply the number of cubic feet in the part of the boat that is below the surface of the water by 62.5; the product will be the load in pounds. For the load specified in the question and a draft of about two feet, a length of 20 feet and width of 14 feet would probably be about right. (*i*) It is impossible to estimate the required size of the cable with any degree of accuracy without knowing the velocity of the current and the sag or deflection of the cable; it is best to be sure to have it large enough. For a span of 1,200 feet, assuming a velocity of 10 miles per hour, a down-stream deflection of 70 feet, and a vertical sag of 30 feet, the required strength would be given by a steel cable 2½ inches in diameter. The ends of the cable must be anchored very securely. (*j*) The cable should be well above high water at the lowest point of its sag, but need not be any great distance above. The connecting or steering rope should be of such length as to allow the ferryboat to float about 20 to 40 feet down stream from the cable, we should say, or a sufficient distance so that its pull on the cable will not be greatly affected by the variation in the height of the water. The best distance for this will therefore depend to a considerable extent upon the amount of variation in the height of the water. Knowing the amount of variation in the height of the water, this can be determined easily by a few trials.

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(461) Mr. A. S. Biggart, in his essay on "Wire Ropes," says that if a wire is bent into a curve of radius R, the intensity of tensile stress due to bending is $f = \frac{E\,I}{2\,R}$, where I is the moment of inertia of the wire, and E the modulus of elasticity of the material. For a rope made of No. 20 B. W. G. wire, bent round a pulley 10½ inches in diameter, he gives f = 112,000 lb. per sq. in., allowance having been made, he says, for the effect of reversed stresses. He also says that, for such a rope, the minimum theoretical diameter of pulley is 6 ft. 6 in. Will you explain how he gets his value (112,000) for f, and the minimum diameter? He takes E = 32,000,000. H. L. D. W.

ANS.—We have not seen Mr. Biggart's essay, and do not know what assumptions he makes nor what numerical values he uses; but probably he arrived at his results in the following manner: The formula for the intensity of stress due to bending is

$$f = \frac{E\,d}{2\,R}, \qquad (1)$$

where d is the diameter of the wire (the substitution of I for d in the formula you quote is no doubt a misprint). The rope under consideration is made of several strands, each wire of which is .035 inch in diameter. Making E = 32,000,000, d = .035, and $2\,R$ = 10.5, the formula gives $f = \frac{32{,}000{,}000 \times .035}{10.5}$ = 106,667 lb. per sq. in. Increasing this value by 5%, in order to allow for reversed stresses, we get f = 112,000 lb. per sq. in. The minimum diameter of pulley is obtained by solving equation (1) for $2\,R$, and putting f the working strength of the material. If we take this working strength as 15,000 lb. per sq. in., we get $2\,R = \frac{32{,}000{,}000 \times .035}{15{,}000}$ = 75 in. = 6′ 3″. Taking f = 14,000, we get $2\,R = 75 \times \frac{14}{15}$ = 80 in. = 6′ 8″. As we said before, we do not know what values Mr. Biggart uses, but the results we have obtained are sufficiently close to his to indicate that he probably followed the same method.

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(462) (*a*) What is the best work that I can obtain to give me a clear idea of the theory and plan of construction of the different methods of geographic projections? (*b*) What are the simplest and best works for a beginner on the elements of astronomy and geodesy? W. O. T., Vernon, N. Y.

ANS.—(*a*) For a general account of several projections, a special account of the polyconic projection, and references to literature we refer you to the Coast and Geodetic Survey Report of 1880, pages 287–296. This book may be obtained by writing to Mr. H. C. Rizer, Chief Clerk United States Geological Survey, Department of the Interior, Washington, D. C. For the fundamental principles of projections, see any work on descriptive geometry. (*b*) Good works on these subjects are "Elements of Astronomy," by Young, $2.00, and "The Elements of

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Precise Surveying and Geodesy," by Merriman, price $2.50. These books may be ordered from The Technical Supply Co., Scranton, Pa.

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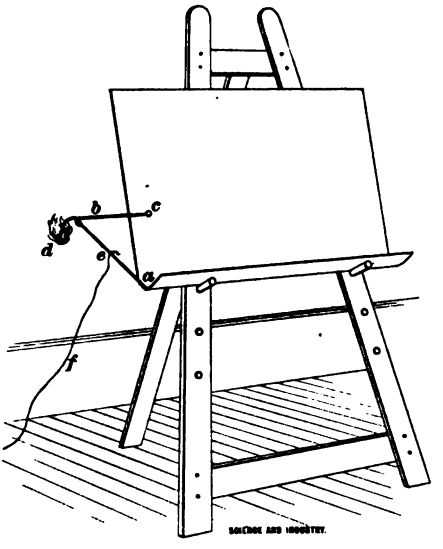
(463) I desire to put off two flash lights at the same time. (a) How can I arrange them so that they will ignite at the same time? (b) What size of spark coil and how many cells of dry battery will be required? (c) How should they be connected?

J. M. C., Pittsburg, Pa.

ANS.—(a) We would not advise the use of two separate flash lights to be set off by an electric current, as they are not likely to explode together, and possibly one may not explode at all. A much more reliable arrangement is used by experienced photographers; it consists of the following inexpensive apparatus: A large sheet of metal (preferably bright tin), the edge of which is bent at an angle as shown at *a* in the illustration, is hung on a wall or supported on an easel above and behind the camera, and flash powder distributed in the trough formed by turning up the lower edge. The flash may be ignited either in the middle or at one end by means of an electric current or by pulling a string. If you use the latter method, the arrangement is as follows: One end of a wire fork *b* is riveted loosely at *c* to the



sheet of tin, and the other end carries a wad of cotton *d* saturated with alcohol. A loose brace *e* maintains the fork in the position shown. A piece of string *f* is carried from *e* to the group to be taken, and when this is pulled it removes the brace *e* and permits the blazing cotton *d* to fall in contact with the flash powder distributed along the ledge *a*. (*b* and *c*) If you prefer to use an electric discharge you will probably require a coil giving at least a ¼-inch spark, and about 6 or 8 cells of dry battery. The two spark gaps would be connected in series across the secondary coil, and the battery would be connected directly to the primary through a push button for closing the circuit.

***

(464) (a) I want to prepare vanishing ink like that mentioned in question 348, in the August issue, but before doing so would like to know whether boiling the nutgalls in alcohol is a dangerous operation, and in what kind of a vessel this should be done. (b) What are the proportions of the chemicals used in this preparation? (c) Will this ink keep for some time, or must it be used as soon as made?

G. S., New York.

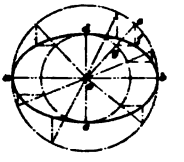
ANS.—(a) The operation is not exactly dangerous, but requires care; a very low heat should be applied. A glass beaker is the most convenient vessel to use for this purpose if small quantities are prepared. (b) We do not know the proportions. (c) The ink will keep for some time in a tightly-stoppered bottle in a dark and cool place.

***

(465) Please explain an exact method for describing an ellipse when both diameters are given.

K. W., Pottstown, Pa.

ANS.—Let *a b* and *c d* be the given diameters of the ellipse, and on these diameters describe circles with their common center at *o*. Draw any radius of the larger circle *o e*. From *g*, where *o e* cuts the smaller circle, draw a line parallel to *a b*, the major axis, and from *e* draw a line perpendicular to *a b*. The intersection *f* of these two lines is a point on the ellipse. Other points are similarly found.



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(466) How do you calculate the time it would take a projectile to strike the ground after leaving the mouth of the cannon with a velocity of 2,000 ft. per second, the center of the mouth being 5 ft. above the ground, and the projectile leaving it at an angle of 45° with the horizontal?

E. R. K., Chicago, Ill.

ANS.—There is no general formula for the solution of this problem. The formulas for projectiles given in ordinary books on mechanics are ideal formulas in which the projectile is treated as a particle, and the resistance of the air neglected. These formulas give tolerably approximate results for small and comparatively heavy bodies moving with low velocities; but, for the practical purposes of gunnery, such formulas are entirely useless. The formula for the time (seconds) of flight of a projectile in a vacuum is

$$t = \frac{v}{g} \sin x + \sqrt{\left(\frac{v}{g} \sin x\right)^2 + \frac{2z}{g}},$$

where v = velocity of projection in ft. per sec.; x = angle of projection; g = 32.16; z = distance (5 ft. in your case) below point of projection at which the projectile is after the time t. In your case,

$$t = \frac{2{,}000}{32.16} \sin 45° + \sqrt{\left(\frac{2{,}000}{32.16} \sin 45°\right)^2 + \frac{2 \times 5}{32.16}} = 88 \text{ sec.}$$

However, as we said above, this is not even an approximation to the true time. The impossibility of solving the problem mathematically is mainly due to two causes: (1) the law of the resistance of the air is not exactly known; (2) even assuming this law (except when the resistance is taken as directly proportional to the velocity—an assumption justifiable only for velocities under 10 ft. per sec.), the equations obtained are so complicated that they cannot be solved. From a great many experiments, tables and empirical formulas have been constructed giving the range, time of flight, etc. of projectiles used in modern warfare under different conditions. For further information on this subject you are referred to the articles on "Gunnery" in the "Encyclopaedia Britannica" (Vol. XI) and in Johnson's "Universal Cyclopaedia" (Vol. IV). We would remark that the angles of elevation used in practice seldom exceed 5°.

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SCIENCE AND INDUSTRY

Vol. V NOVEMBER, 1900 No. 10

THE HOUSING OF THE STEEL STEED

H. T. Bentley

MAMMOTH ROUNDHOUSE OF THE CHICAGO AND NORTHWESTERN RAILWAY CO.—ELECTRICALLY-CONTROLLED TURNTABLE—PNEUMATIC OIL TANKS AND ASH CONVEYORS

"Brave racer, who hast sped the living light
With throat outstretched and every nerve a-strain!"

IN ACCORDANCE with the decree of Dame Nature, every one of her children, whether animate or inanimate, in order to maintain their normal strength, must have rest and relaxation. The modern locomotive, with its hundred tons of "tissue, bone, and muscle" and a complete system of "nervous fiber" under the highest tension when in service, is not exempt from this mandate. This sinewy centaur, whether a "pony" or a "hog," must be regularly side-tracked from the race course to the stall, where it can rest while being groomed, broomed, and fed. Dusty roads, a scorching fire, and an inexorable driver, who must "make time," have rendered Hercules much the worse for wear and tear. His lungs must be cleared, his digestive organs flushed, his muscles and joints lubricated, his system toned, and his trappings polished like "the handle of the big front door."

To meet the fastidious demands of this latter-day son of the chase, Science and Art have willingly become his handmaidens and continually cater to his care and comfort. Substantial structures, known to the world as "roundhouses," have been erected and equipped with every conceivable device for "tabling," "bathing," and "massaging" this brave racer at the close of his daily contest with time and the elements. His headlight is lowered, and when "no long-streaming beam of light comes trembling through the gloom" he is turned over to his house attendants.

Who, having entered a roundhouse, has not been impressed with the majesty of Hercules and Goliath at rest?

"At intervals they darkly stand,
No words come forth:
Each soul is rolled into itself!"

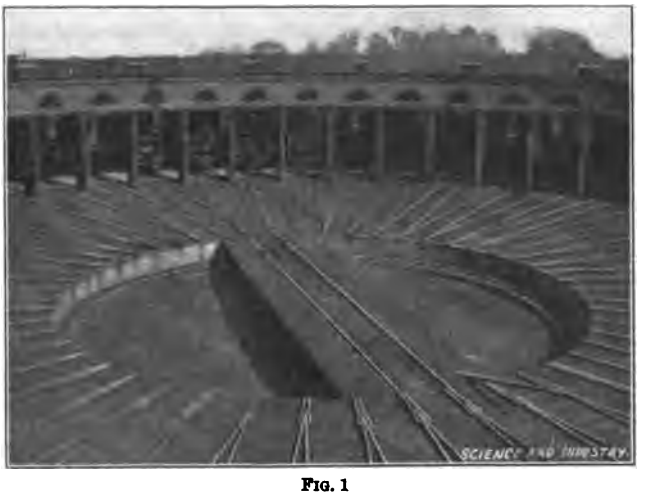

FIG. 1

Among the recent acquisitions to the homes for fatigued motors is the splendid roundhouse lately completed for the Chicago and Northwestern Railway Company, at Clinton, Iowa, which is said to be the largest and finest in the United States, if not in the world. This mammoth rotunda contains no less than fifty stalls for the largest type of

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FIG. 2

the present-day locomotive, with liberal allowance for increase in future types. As two of the stalls are assigned for entrance and exit, there is an actual housing capacity for forty-eight locomotives. The "round" house is so in reality, as it forms a complete circle and is charged or discharged by means of an electrically-controlled turntable 70 feet in length. This turntable is shown in Fig. 1, which also shows the radial tracks leading to the stalls and a series of the stalls in the background. The doors are wide open and held in place by approved fastenings. The inner radius of the outer wall is 187 feet 6 inches and that of the inner wall is 106 feet, giving a clear distance between walls for the housing of the locomotives of 81 feet 6 inches; the length of the longest engine at present is 62 feet 8½ inches, so that a passageway, or clearance, over 9 feet in width exists at both the front and rear of the engines, when in range, as shown in Figs. 2 and 3. The exterior diameter of the structure is thus nearly 380 feet, and the interior diameter of the interior court about 210 feet. The stability of the structure is insured, as it is founded on solid rock, out of which the pit for the turntable and the drop pits for the engines were excavated.

The outer wall of the building is constructed with a good grade of rubble masonry, and is faced with squared rock-faced ashlar up to the window-sill course. This course also forms a water table from which rises the superstructure of brickwork, each bay, or stall, being emphasized and reenforced by pilasters. The pilasters carry a corbeled frieze surmounted by a corbeled band of brickwork and a parapet, which is at once a logical and effective architectural treatment for structures of this class. The framework and roof is of slow-burning construction, and is substantially braced and anchored to the brick walls of the superstructure. The floor is finished with hard-burnt bricks set on edge, and this furnishes a lasting and durable surface that is preferable to wood, both on account of cleanliness and of permanence.

It might not occur to the reader that the heating of such a building is a matter that requires considerable attention. Even the steel giants, like their human brethren, must be kept in a properly heated apartment while they are at rest, and if the temperature is not properly regulated, the exposed parts are liable to freeze and burst.

When man is asleep the blood circulates

FIG. 3

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FIG. 4

slowly and vitality is low; intense cold will then readily congeal the blood and stop circulation. During waking hours the same degree of temperature will not produce the same effect, especially if the subject is walking or running, because the heart, or circulating pump, keeps the vital fluid moving quickly through the proper channels and prevents congelation. It is likewise with the locomotive; when the fire is "banked" the circulation is very slow, and the water in the chambers and tubes is rendered very susceptible to freezing; when it is rushing through space, however, although exposed to the keenest and most biting winds, it is comfortably warm, because the fire is then burning briskly and furnishes a high vitality and an active circulation, and the water elves refuse to flirt with Jack Frost.

The health and comfort of the attendants must also be considered, and these in turn will affect the character of their work. It is therefore essential that a first-class system of artificial heating and ventilation be installed in every up-to-date roundhouse. A series of stoves or a system of steam pipes may furnish heat, but in conjunction with the heating of the building the matter of ventilation must receive attention. Ventilation affects not only the health of the men but the efficiency of the engines and the durability of the structure. Coal, particularly anthracite, during the process of combustion, gives off a mixture of gases known to scientists as carbonic acid, carbonic oxide, sulphurous, etc., but to the general public they are simply furnace gases. These gases accumulate in the building regardless of all the individual smoke flues arranged over the smokestacks. They impoverish or poison the blood of the workmen, rust the engines, and attack the ironwork of the roof, etc. A system of ventilation to be effective should quickly remove the gases from the building and supply fresh air at a temperature of about 60° F.—a comfortable temperature for men to work in. Such a system has been installed in the Clinton roundhouse shops, for which the employes are grateful to the company. It means to the men not only the maintenance of vigor but the preservation of health. The installation is composed of a fan of the centrifugal type and a system of main and branch flues arranged and proportioned to suit conditions and requirements. The fan blows fresh air into the building and forces out the obnoxious gases. The air is warmed by being passed over a stack of steam pipes either before or after leaving the fan. The temperature of this air can be adjusted by the attendant by shutting off or turning on sections or sub-

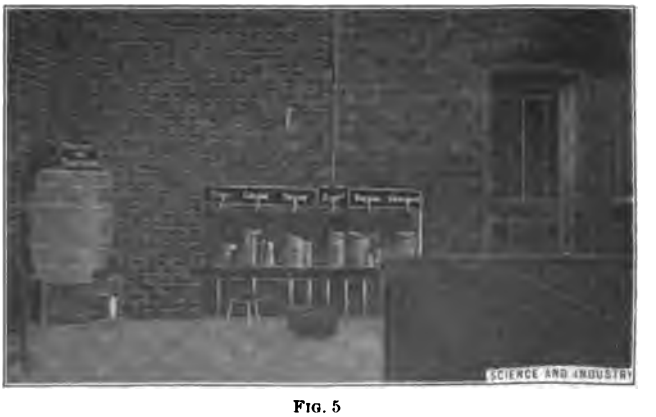

FIG. 5

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divisions of the stack. A conduit conveys the air from the fan to the pits under the engines and to the spaces over and between the engines. In this way the warm air is introduced into the building at many points at the top and bottom, so that the temperature throughout the structure is as near uniform and the ventilation as nearly perfect as can be devised.

The water supply for the plant is obtained from an Artesian well 1,175 feet in depth, sunk on the premises.

In addition to the roundhouse proper there has been erected a machine shop and storeroom 60 × 140 feet. In the machine shop are vises, lathes, planers, etc., so that all ordinary running repairs can be executed. A portion of this shop is shown in Fig. 4. The roundhouse, machine shop, and storeroom are heated by the Sturtevant hot-air system, of which some of the delivery pipes are shown in Fig. 4.

The oil room, which is in a fireproof building, is a model of its kind, and was specially designed by Superintendent of Motive Power and Machinery, Robert Quayle, of Chicago. The building is 33 × 35 feet, and contains twelve underground oil tanks. The oil from these tanks is raised by air pressure, so that it can be readily drawn off at the faucets instead of being pumped in the usual manner. An interior view of the oil room with its furnishings is shown in Fig. 5.

The large amount of ashes to be handled and discharged daily in such a structure, where so many engines are housed, required the design of a system that would speedily collect and effectively dispose of car loads of waste material. This was undertaken by Mr. Henderson, the Assistant Superintendent of Motive Power and Machinery of the company, who has perfected an ash hoist well fitted for the service. In the old-style clinker pits, the cinders were shoveled out of the pit on to the floor and thence into a car, while in later styles the car was run on a depressed track, thus facilitating the handling of the material. At best, however, this was a slow and unsatisfactory method, as it was necessary to keep engines off the pit while the shoveling was going on. With the pneumatic system of handling the ashes, installed in this new plant, it is possible for a man to stand in the pit, and by operating a valve, convey the cinders from the pit to an ash car standing on a near-by track, and when the car is filled it is run outdoors to the ash hoist and dumped into large cars. This ash hoist, which is pneumatically controlled, is shown in Fig. 6, and consists of a series of inclined planes over which the ash cars travel, the cars being attached to cables connected with the gearing of the pneumatic cylinders. In operation the car is hauled up the plane, as is seen in the figure, to the apex, where, by an ingenious device, the car door is opened and the ashes dumped, after which the door automatically closes, the car descends and returns to the pit for another load. It will be seen that with this system all of the ashes can be removed while an engine is over the pit, or even while it is being moved from it, and thus time is gained by this independent manipulation.

FIG. 6

In Fig. 7 is shown a sand tower in which is stored prepared sand for locomotive use. The sand, having been duly dried and sifted, is forced by pneumatic pressure up into the tower, from whence it descends by gravity through the delivery tubes to the sandboxes of the engines.

Since 1864 the engines of the Iowa and Galena divisions were housed in a roundhouse having but twenty-five stalls, so that in the event of forty or fifty engines being run in on the section no proper accommodation could be provided. The family of locomotives not only outgrew

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the capacity of the old quarters in numbers, but also in bodily dimensions, necessitating the erection of an extension or vestibule around the structure, so that the giant "freighters" of the class "R" type could be protected from the elements and the outer doors closed. This furnished only temporary relief, however, and a year ago the company decided to erect the spacious and substantial structure that now holds the record as the largest and best-equipped roundhouse on the continent.

FIG. 7

The site of the buildings is between Comanche Avenue and the freight yards, and is an ideal location. The short time required to erect the structure is also a source of pride to the officials of the company. The excavation was commenced on August 14, 1899, and by May 14, 1900, the building was ready for occupancy—a creditable performance in nine months, and that during the winter. The construction was directed and supervised by W. D. Walden, Superintendent of Bridges and Buildings, and the buildings are certainly a monument to his energy, tact, and ability. Mr. Walden, nevertheless, has entered the patriarchal era, being 75 years of age, and is yet in the harness; he is an indefatigable worker and for the past 37 years has been in the employ of the Chicago and Northwestern Railway Company.

It is interesting to note that while this veteran was a "tot" of four years of age, the first locomotive run in this country was manned by Horatio Allen, who made the trial trip from Honesdale, Pa., on August 9, 1829. This hissing and fuming broncho, grandiloquently styled "The Stourbridge Lion," was built in England under the direction of Mr. Allen, who certainly had the courage of his convictions and the faith of a martyr. Upon placing his hand on the throttle valve he quaintly remarked: "If there is any danger in this ride, it is not necessary that the life and limb of more than one should be subjected to that danger."

Thus in the course of a single lifetime the entire railroad system of this country has been developed, equipped, and brought to its present state of perfection. Today, no less than 36,746 locomotives have to be housed after their day's labor so that they may enjoy a well-earned rest, for without it—

"The splendor of strong life must wane."

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THE LATHE INDICATOR AND THE CENTER INDICATOR

John A. Grening

CONSTRUCTION OF THE LATHE INDICATOR—TESTING WORK—CONSTRUCTION OF THE CENTER INDICATOR—HOLDER FOR INDICATORS

THERE are two instruments that are extremely useful to the machinist and toolmaker for doing lathe work requiring the utmost degree of accuracy. These are known technically as the lathe indicator and the center indicator. Both of these instruments have but recently been placed on the market, and are still comparatively unknown except in the best shops. Nearly all of those in existence have been made by the machinist or toolmaker himself; as a consequence, there is a great variety of designs, gotten out in accordance with the ideas of the men who made them for their own use.

The following are descriptions of these two instruments, which have been designed, made, and used by the writer, and of a holder for them that was designed and made by a friend, who intended to use it for a thread-cutting tool. The designs given are not claimed to be the best that could be devised, but are given merely as a suggestion of how such instruments may be made. Actual use has proven them to be satisfactory as far as the writer is concerned. Their construction is not covered by patents, so that any reader who thinks the designs given will suit him is at liberty to construct them.

The lathe indicator is shown in Fig. 1, the illustration being full size. The purpose of the indicator is to magnify any untruth of the work, in order to make the error more visible. The most obvious and direct method is to use a lever with a long and a short arm. The short arm bears against the work. When the latter is revolved in the lathe any error, due either to the work not being round or to its not being set centrally, causes the end of the long arm to describe an arc, the length of which is directly proportional to the ratio between the lengths of the two arms. In other words, the longer the long arm is made in proportion to the length of the

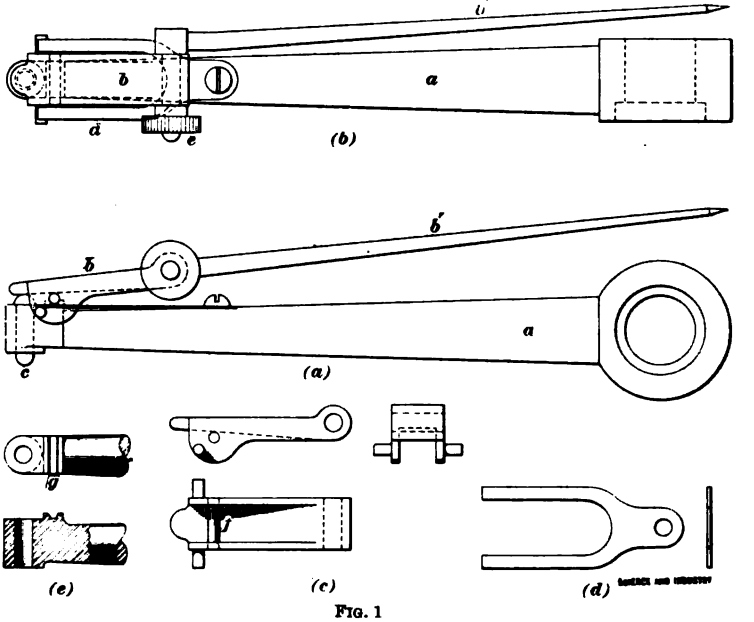

FIG. 1

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short arm, the more sensitive the indicator will be. In practice, it is rarely necessary or advisable to make the ratio more than 1 to 50; with this ratio, an error in the work amounting to only .0001 inch will cause a movement of the long arm through an arc fifty times as long, or .005 inch in length. This is an amount that can plainly be seen with the naked eye. If the indicator is more sensitive than this, it is too liable to be affected by the vibrations of the floor and machinery that exist to a greater or less degree in all shops. For special work requiring the greatest degree of accuracy, an indicator may be constructed with a greater degree of sensitiveness than that here recommended as the limit for general work; in that case, it must be used in a place free from vibrations.

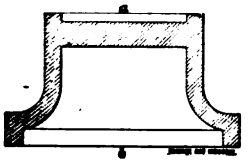

FIG. 2

Referring to Fig. 1, views (*a*) and (*b*) are, respectively, a side elevation and a plan view of the indicator. It consists essentially of four parts. These are the body *a*, the lever *b*, the feeler *c*, and the spring *d*. For convenience, the lever is divided into two parts, *b* and *b'*. They are so formed that *b'*, which forms part of the long arm of the lever, can be swiveled to any convenient position within range. By means of the locknut *e* the two parts may be locked together after the adjustment. The division of the lever into two separate parts also allows the degree of sensitiveness to be increased or decreased by the substitution of different arms. The end carrying the feeler is hardened; the hole that receives it is lapped true and smooth. The feeler itself is hardened, ground, and lapped so as to be a good sliding fit in the hole. Both of its ends are hemispherical; the upper end is enlarged, to form a stop. The chief peculiarity of the lever is the manner in which it is fulcrumed, the fulcrum being so designed that not only is all wear taken up automatically, but also the possibility of any lost motion at the fulcrum is done away with. This is done without the introduction of any complicated device.

Referring to view (*c*), which is a detail drawing of the main part of the lever, it is seen that the fulcrum pin *f* is held by its ends in the two wings that straddle the end of the body *a*. This pin is hardened and lapped smooth; it is then driven home. The seat or bearing for the fulcrum pin is shown in view (*e*). A slot *g*, about two-thirds of the diameter of the pin in width, is cut to a depth sufficient to have the pin clear the bottom of it. The upper edges of the slot are slightly beveled; the fulcrum pin rests on these two edges. It is held down to its seat by the straddle spring, which, by reason of its bearing on the lever between the fulcrum and point of contact at the feeler, holds the fulcrum pin down, prevents any lost motion, takes up any wear, and also causes the lever to follow any sliding motion of the feeler. The straddle spring is shown in view (*d*). It should be a rather stiff spring; if made of the size shown in the drawing it should be made from sheet steel $\frac{1}{32}$ inch thick.

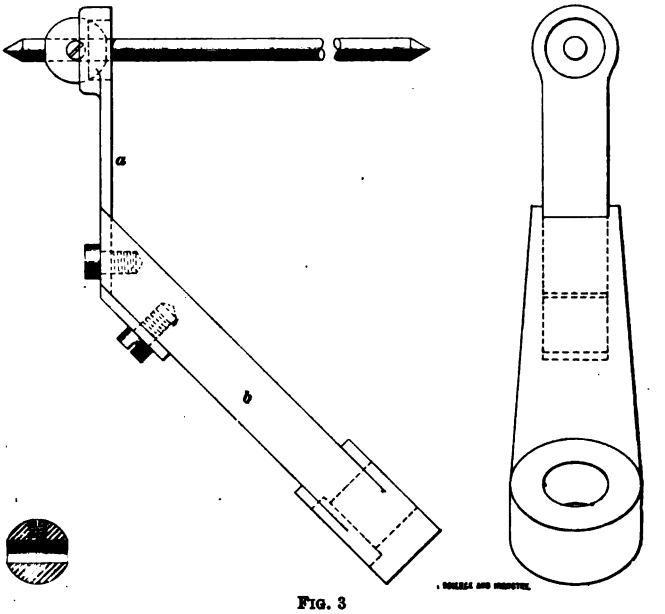

FIG. 3

Suppose it is desired to test a piece of work to find out whether it runs true on dead centers. Place the work between the centers of the lathe, and, after attaching the

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indicator to its holder, which is shown in Fig. 4, adjust it so that the feeler will bear hard on the work to be tested, and be about perpendicular to the surface of the work. Rotate the work between the centers by hand and watch the end of the long arm. If it moves, it indicates one or both of two things: (1) the work may not be cylindrical; (2) the work may be eccentric in regard to the centers on which it has been finished.

A good idea of the kind of error may be formed by carefully watching the movement of the end of the lever. If it vibrates steadily just once for each revolution of the work, the latter is most likely to be round, but not central in regard to its centers. If the pointer moves in jumps, i. e., makes several vibrations during one revolution, the work is most likely to be out of round and it also may be eccentric. To test its roundness, caliper it in a number of directions, preferably with a micrometer. When the work is eccentric, it can often be made central in regard to its centers by carefully lapping the center or centers with a brass lap charged with emery, provided the error is very small, say .0005 inch. When the end of the long arm remains stationary it shows the work to be both round and concentric with its centers.

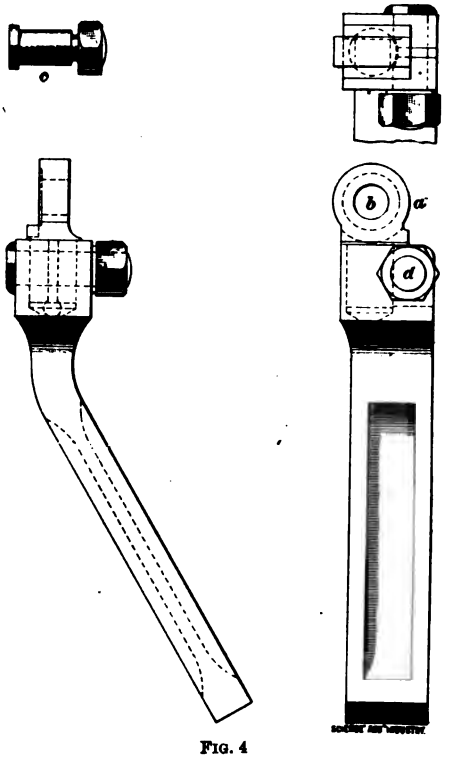

FIG. 4

The indicator may be applied to a hole in a piece of work held in the chuck or on the face plate, for the purpose of finding out whether the axis of the hole coincides exactly with the axis of the spindle; in other words, to find out whether the hole runs true. If the hole is too small to admit the feeler of the indicator, grind up a cylindrical plug to fit the hole nicely, and apply the indicator to the outside of the cylinder. The indicator may also be applied to the face of work, to see whether it has been faced true or whether it runs true sidewise; likewise, it is of great assistance in rechucking or resetting cylindrical work that is required to be chucked with great accuracy.

The particular design of indicator here shown, being removable from its holder, can be attached to a surface gauge and may then be used for testing the parallelism of straight surfaces. As is well known, it is very difficult to measure the parallelism of straight surfaces when they are far apart; in many cases calipers cannot be applied at all. For instance, consider the piece shown in Fig. 2. The question arises as to whether the plane of the circular ring at *a* is parallel to the plane of *b*. Evidently, this cannot be measured by calipering. But if the indicator is attached to a surface gauge, the work may be placed on a surface plate and the feeler brought in contact with the ring *a*. If its pointer remains stationary while the feeler is moved around the ring, the surfaces are parallel.

In order that a small motion of the end of the pointer will be visible, it is necessary to have some stationary point near it. The writer has used for this purpose a thin metal disk with a piece of soft brass wire, pointed at the end, soldered to it. The disk was placed between the joint of the holder and the joint end of the indicator; the brass wire was then bent to the shape required. If desired, some more elaborate construction may be employed.

The center indicator shown full size in Fig. 3 is intended to aid in the proper location of work that is to be chucked, so that a center punch mark will coincide with the axis of the live spindle of the lathe—that is, run true. The tool is essentially a lever with a long and a short arm turning about a ball joint as a fulcrum. The indicator is clamped to the tool holder shown in Fig. 4,

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which is held in the tool post of the lathe; the carriage is then run forward until the pointed end of the short arm bears lightly in the center punch mark in the work. The part *a* is made thin so as to form a spring that will hold the pointer in the center punch mark. If, on revolving the headstock spindle, it is found that the end of the long arm moves in a circle, it shows that the center punch mark is not in the axis of the spindle, and the work needs moving until the end of the pointer remains stationary, when the spindle with work attached to it is revolved. It is necessary to have some stationary point by which to observe the motion of the pointer; the dead center is the most convenient point to use.

If the indicator is connected to a holder in such a manner that it can be swiveled up and down, it can readily be used in all sizes of lathes. The center indicator shown possesses the advantage that there are no joints, and its accuracy is not disturbed by wearing of the joints. Furthermore, the pointer is adjustable for different degrees of sensitiveness; a small setscrew in the ball, a section of which is shown separately, is used for clamping the pointer and ball together. It is scarcely advisable to make the pointer longer than 15 inches; this length will be found to answer very well indeed. If made longer, the tool will be affected too much by the vibration of the machine.

The pointer, the ball, and the head *a* should be made of tool steel and afterwards hardened. The head *a* must be drawn to a spring temper, since it serves as a spring. The ball and the end of the pointer may be drawn to a straw color. Grind together the ball and the seat in the head, using the finest flour emery. The shank *b* may be made of machinery steel and case hardened.

The holder shown in Fig. 4 is made of tool steel. Its head *a* has a cylindrical hole *b* to receive the clamping bolt *c*, by means of which the indicators are attached. The head has a cylindrical shank closely fitted to a hole in the holder proper. The holder is split at the front end; a clamping bolt *d* allows the head *a* to be locked in any position after rotation to the desired place. The combination of two joints allows a movement of the indicator in two planes perpendicular to each other; hence, the indicator can be swung through a very wide range of positions, and is then adapted to almost any size of lathe and any kind of work conceivable. It is advisable to harden the holder at a rather low heat, and then draw it to a spring temper.

TESTING, ADJUSTING, AND READING THOMSON RECORDING METERS

W. H. Fellows

TOOLS AND INSTRUMENTS REQUIRED—TESTING TWO- AND THREE-WIRE METERS—ADJUSTING AND CALIBRATING—DIRECTIONS FOR TAKING READINGS

THE flat-rate consumer has been, and is now, gradually disappearing; in his place is found the one that pays for his electrical energy on a meter basis. Now, the electric meter is held responsible for nearly all the earnings of a company, with the exception of what comes from the series arc system.

Since a very large proportion of the station's total output goes to supply loads of one, two, or a few lamps, the meter should register with a fair degree of accuracy on these light loads, as well as on the greater loads. The up-to-date central-station manager has come to realize that the meter will soon more than pay for time spent on it in putting it in good running order. On the other hand, a consumer complains that his meter certainly must be running too fast. (It can be counted on that he will not complain in the other direction.) It will, therefore, be seen that methods should be available for testing meters so as to bring about a feeling of security and satisfaction to the manager; also, to ascertain whether the consumer has just grounds for complaint.

In the following, the writer will endeavor to describe some methods and hints applicable in testing and adjusting Thomson recording watt-hour meters, which he has picked up in a company having installed over 1,300 meters, about half of which are Thomson meters.

The meter will be regarded as installed in

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the place where it has rendered or is to render service, since it is there that the conditions under which it is to operate are met with.

The methods pointed out will also be found valuable in the laboratory. The following instruments and tools will be found serviceable:

1 pair of 6-inch side cutting pliers.
1 pair of 6-inch gas pliers.
1 pair of tweezers.
Screwdrivers suitable for different screws in meter.
1 pocket kit of meter tools (put up by the General Electric Company).
1 8-inch or 4-inch fine-grained flat file.
1 small rubber syringe.
1 old shaft, for holding shaft ends.
Sticks (boxwood, very good) for cleaning between segments of commutator.
1 good stop-watch.

FOR ALTERNATING-CURRENT WORK

1 standard voltmeter.
1 standard indicating wattmeter (its capacity depending on capacity of meter to be tested).
1 standard lamp (calibrated for watts at different voltages).

FOR DIRECT-CURRENT WORK

1 Weston voltmeter.
1 Weston millivoltmeter and shunt (capacity of shunt depending on capacity of meter to be tested).
Connectors and cables are to be of such forms and carrying capacities as will be necessary for making required connections.
Piece of cotton cloth.
Roll of ½-inch white cotton tape.
Sheet of crocus cloth.
Gasoline, for cleaning train of counter.
A good portable lamp bank.

To carefully test a meter on the circuit, the services of two men will be required, a tester and a helper—one to count the revolutions and one to watch the instruments. It is advisable to take a statement of the meter before touching it at all. Then remove the cover and proceed to connect the standard instruments according to the diagrams given.

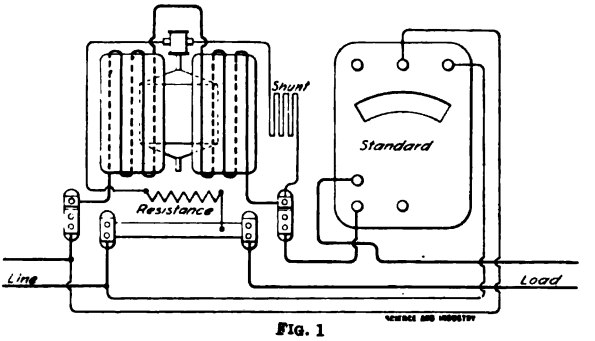

FIG. 1

Figs. 1 and 2 show proper connections on two-wire meters. It will be noticed that the energy consumed in the potential circuit of either of these meters is not measured by

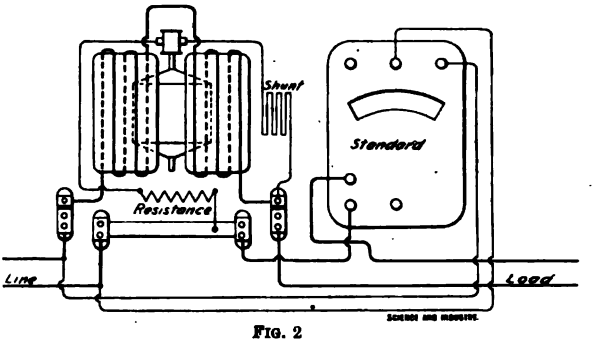

FIG. 2

the other; that is, the current of the armature in the Thomson meter does not pass through the fields of the standard meter; neither does the current of the shunt in the standard pass through the field coils of the Thomson meter.

Standard instruments of too large a capacity should not be used, since the readings will be too far down on the scale and cannot be relied on within a fair degree of percentage error. Two standard meters of different capacities will often be found necessary. For example, let us say that a 50-ampere Thomson meter is to be tested. Then, a 50-ampere standard and a 10-ampere standard will make a very convenient combination. With direct current, the combination of shunts, of course, makes a very flexible arrangement. For very low loads on smaller meters, the standard lamp previously mentioned will come into service, especially in alternating-current districts.

Having the standard instruments properly connected, one man reads the instruments while the other counts the revolutions of the disk for from 40 to 60 seconds, or even longer. The time of the revolutions is read from the stop-watch, and the meter watts are calculated from the following formula:

$$\text{Meter watts} = \frac{R \times K \times 3{,}600}{T},$$

in which

R = number of revolutions in T seconds;
T = time, in seconds, of R revolutions;
K = constant marked on dial.

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$$\text{Efficiency (per cent.)} = \frac{\text{meter watts}}{\text{standard watts}}.$$

The standard watts are the mean of volts × amperes on direct current, or the mean

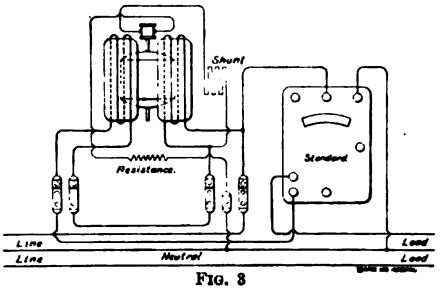

FIG. 3

reading of a standard wattmeter on alternating current.

It is always well to check a test on any given load.

EXAMPLE.—A meter is a 10-ampere 100-volt Thomson, and the disk makes 10 revolutions in 60 seconds. Then, meter watts $= \frac{10 \times \frac{1}{2} \times 3{,}600}{60} = 300$. The mean standard watts, as indicated by the standard meter or meters, is 303. Per cent. efficiency $= \frac{300}{303} =$ 99, about; or, the meter is 1 per cent. slow.

This method of procedure and formula may be used to test the efficiency of the meter on any load, although it is hardly practicable to go below 5 per cent. of the rated capacity of the meter.

THREE-WIRE METERS

The potential circuits of these meters are wound for 110 volts in meters rated at 220 volts. The coils can, therefore, be connected in series (Fig. 3) and tested on a 110-volt current. In the formula, however, K should be regarded as one-half of the constant marked on the dial. Aside from this, the meter can be tested in the same manner as a two-wire meter.

Fig. 4 shows a method of bridging and connecting a three-wire meter for testing, with a cut-out on both the line and the load side. The bridging is only necessary where a consumer wishes to use current during the test.

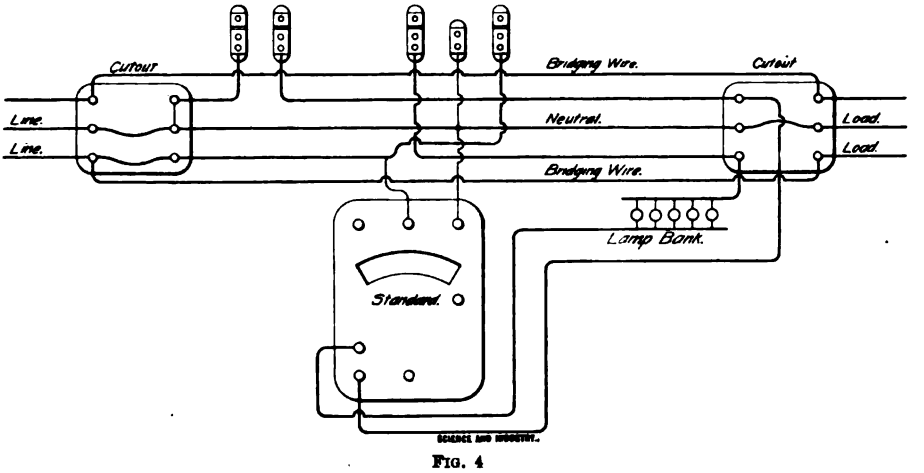

FIG. 4

PRIMARY METERS

These are 50- or 100-volt meters with a special transformer to transform from the primary voltage to the voltage for which the meter is wound. They can be tested on a secondary circuit having the same voltage as the secondary voltage of the meter transformer. The value of K in the formula is equal to the constant marked on the dial divided by the ratio of transformation. For example, the line voltage is 1,000; the secondary voltage is 100; the constant on the dial is 10; hence, $K = 10 \div 10 = 1$. If the meter is for a very high-voltage circuit, then current transformers are used, and the ratio of transformation of current has to be taken into account. For example, the voltage transformed is from 5,000 to 100; the current ratio is 3 to 1; the constant marked on the dial is 150; then, K in the formula $= 1$ when the meter is tested on a 100-volt circuit.

After testing the meter on different loads, it will, in all probability, show an error somewhere if it has been installed any length of time. It will generally be found slow on light loads, due to friction. About

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the first thing to do is to clean the meter thoroughly. Blow the dust out with the small syringe, and wipe out with a cotton cloth the parts that can be reached. Clean out the top bearing and worm gear, but never oil them, as the oil is liable to find its way to the commutator. If the train of the counter is stiff, a bath in gasoline will generally be found an excellent remedy. Next see that the brushes present a clean, flat, smooth surface to the commutator. A piece of crocus cloth glued to a narrow thin stick answers the purpose for polishing the brushes, except in cases where grooves are worn in them. Then a small flat, fine-grained file may be used first. After the brushes are put in proper shape, the commutator can be polished with the narrow cotton tape; where necessary, a narrow strip of worn crocus cloth may be used first. To use the crocus cloth and tape, pass it around the commutator, cross the ends in front to prevent catching the brushes, then pull back and forth, twirling the rotating part. The spaces between the segments can be cleaned with a stick whittled to a flat point.

Next examine the jewel and shaft end. The jewel can be tested with a fine-pointed needle. If found rough or scratched it should be replaced with a new one. The shaft end can be removed with a special tool found in the repair kit. It can then be screwed into the end of an old shaft, when any roughness can be detected by rubbing it over the finger nail. If found rough, a new shaft end should be put in. When the new jewel is put in, it may leave the rotating part too high or too low for the worm and wheel to mesh properly. Adjustment can be made in this case by loosening the jam nut just under the collar of the disk. A drop of good clock oil may be put on the jewel, except when the meter is located in a dusty place.

The meter is now ready for adjustment. It should be made as nearly correct as possible on about full load by moving the dampening magnets. To move these, loosen the screws underneath the meter. The meter is slowed down when the magnets are moved away from the shaft, and is speeded up when they are moved toward it. If it is found that the meter will not come up to speed with the magnets as far in as they will go, there is probably an open circuit in the armature. If this is the case, the meter will show an error in the neighborhood of 30 per cent. Again, if the meter cannot be brought down to proper speed, the magnets may be too weak or there may be a short circuit in the envelope resistance.

After adjusting at full load, drop down to, say, a 5-per-cent. load. The brush tension may here be changed to bring about proper speed. To weaken the tension, push the brushes back away from the commutator far enough to make a set in them. To strengthen the tension, use the small pointed instrument that is provided with the repair kit, and push straight back, just where the brush starts on its first convolution. Never leave the brushes so loose that sparking at the commutator will result. When the meter is once properly adjusted on these two loads it will generally be found correct on any other load up to its rated capacity.

If a meter is located in a place where there is vibration, it may be found to creep. This can be stopped by shunting the compensating coil. When this is done, efficiency on light loads is generally sacrificed. Vibration will shorten the life of the jewel and cause sparking at the commutator. Hence, meters should be located in places as free from vibration as possible.

Reading meters is considered a difficult task by many, but once the dials are thoroughly understood there should be no trouble in reading correctly. The main point is to exercise care. With a little practice it will be found that a dial can be read with almost as much ease as a row of figures. Fig. 5 illustrates dials of meters with the pointers in various positions. Some of them have the pointers so situated as to often puzzle the beginner. We will give the reading of each, and endeavor to explain why each should be read as given. A thorough knowledge of the six readings should enable one to read almost any meter.

The lowest reading pointer is the one to the extreme right (facing the meter). One complete revolution means 1,000; each division, therefore, is 100. The next one to the left is 10,000 to a revolution, or 1,000 to a division, and so on. It will be seen that the ratio of velocities of neighboring pointers is 10 to 1, the wheel of the shaft to the right gearing into the pinion of the shaft just to the left of it. This accounts for the alternate directions of rotation of the pointers.

Beginning at the left, number the pointers 1, 2, 3, 4, and 5. Then in *I*, Fig. 5, No. 5 pointer is on *2*, and is read "200." No. 4 pointer is two-tenths of the way between *8* and *9*, and is read "8,000." No. 3 is read "10,000." No. 2 has not gone through its

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first division; likewise, No. 1. The statement is then 18,200, and is to be multiplied by the constant of the meter, to reduce to watt-hours.

The statement of *II*, Fig. 5, is 5,718,900, (not 5,719,000 as it frequently would be read). No. 4 pointer should not be read "9" until No. 5 has completed its revolution and is again at zero.

The statement of *III*, Fig. 5, is 99,800, (not 109,800), because the 100,000 mark will not be reached until pointer No. 5 has passed from *8* to zero, when No. 4 and No. 3 will be at zero, No. 2 at *1*, and No. 1 just past the zero mark.

The statement of *IV*, Fig. 5, is 9,990,800. No. 1 pointer is slightly misplaced. Otherwise, the reasons given above will apply to this statement.

The statement of *V*, Fig. 5, is 8,619,900. No. 2 pointer is misplaced; for it should be two-tenths of the way between *6* and *7*, instead of directly over *6*, as shown.

The statement of *VI* is 835,200 (not 834,200). No. 4 pointer is misplaced. It should be about the same distance on the other side of *5*. These misplaced hands are frequently met with in practice, and are generally caused by a knock in removing the cover, or perhaps they are a little eccentric.

To ascertain the number of watt-hours that have been used by a consumer from one date to another, subtract the earlier statement from the latter, and multiply by the constant of the meter. Or, multiply both statements by the constant, then subtract. The writer prefers the latter method, for the reason that, if a mistake is made in multiplying by the constant, the error will naturally be compensated for at the next reading. An illustration of this will be given later.

To illustrate how the consumption in watt-hours is obtained, let us take some of the dial readings of Fig. 5. The constant of the meter is ½.

Statement January 30 (*V*)	= 8,619,900
Statement February 28 (*IV*)	= 9,990,800
Statement March 31 (*I*)	= 18,200
Statement April 30 (*III*)	= 99,800

Watt-hours January 30 to February 28 = (9,990,800 − 8,619,900) × ½ = 685,450; or ½ of 9,990,800 − ½ of 8,619,900 = 685,450.

Watt-hours February 28 to March 31 = ½ of 10,000,000 − ½ of 9,990,800 + ½ of 18,200 = 13,700. This means that the meter has run up to its highest reading point, and has registered anew 18,200 × ½ watt-hours.

Watt-hours March 31 to April 30 = 99,800 × ½ − 18,200 × ½ = 40,800.

Suppose that the January and the February readings were taken and subtracted, and then multiplied by ½, but that an error was made in multiplying that brought the consumption up to 680,450 watt-hours. Now,

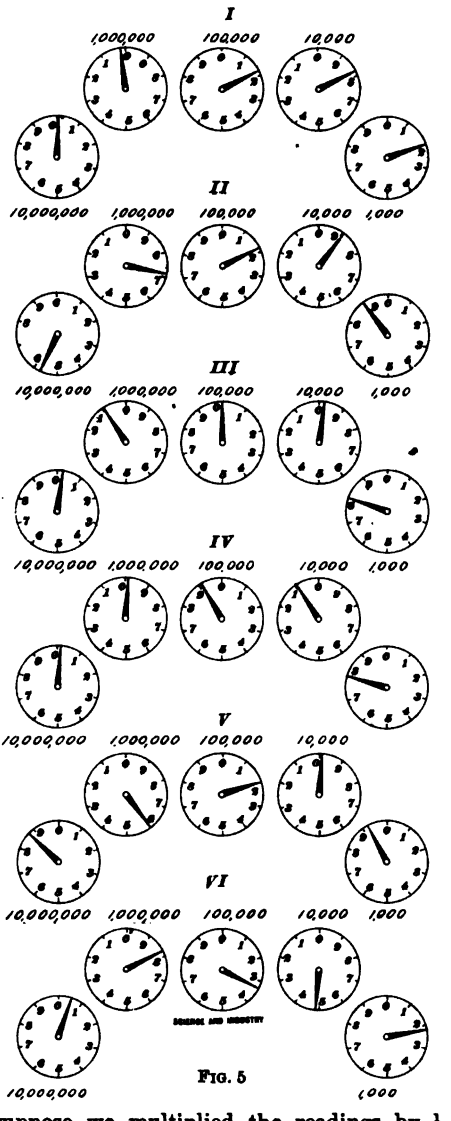

Fig. 5

suppose we multiplied the readings by ½ first, making February 28 = 4,990,400 and January 30 = 4,309,950. It will be seen that a mistake has been made in multiplying the February reading, as it is 5,000 low. This is equal in amount to the error made under the first method. As a starting point

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from which to figure the bill covering the period between February 28 and March 31, 4,990,400 has been entered in the books. But this is 5,000 lower than it should be. Therefore, the watt-hours billed March 31, will be 18,700 instead of 13,700, thus compensating for what was lost the previous month.

In conclusion I would say, exercise care in every instance. Do not slight details in working on meters. The details make up the whole. The one that pays close attention to these points and is energetic should make a valuable man to care for meters.

A FAMOUS PARADOX

George McC. Robson, M. A.

ZENO'S ATTEMPT TO DISPROVE THE REALITY OF MOTION—DIOGENES' REPLY—SUM OF AN INFINITE NUMBER OF TERMS—PRODUCT OF AN INFINITE NUMBER OF FACTORS

THE following question from a subscriber relates to a matter which is both interesting and important, and which has puzzled a great many people. Therefore, we have decided to make it the subject of an article.

The question is: The dial of a clock is 1 foot in circumference; at one o'clock the points of the two hands are $\frac{1}{12}$ of a foot apart; when the minute hand has covered the distance, the hour hand has advanced $\frac{1}{12}$ of $\frac{1}{12}$ of a foot, or $\frac{1}{12^2}$ of a foot; when this $\frac{1}{12^2}$ of a foot has been covered by the minute hand, the hour hand has advanced $\frac{1}{12}$ of $\frac{1}{12^2}$ of a foot, or $\frac{1}{12^3}$ of a foot. In this way, the distance the hands are apart, which may be represented by x, is made to have successively the values $\frac{1}{12}, \frac{1}{12^2}, \frac{1}{12^3}, \frac{1}{12^4}$, etc. of a foot. Thus, the successive values of x are found from the equation

$$x = \frac{1}{12^n}, \qquad (1)$$

by giving n successively the values 1, 2, 3, 4, etc. Now, (a) is the value of x ever reduced to zero? (b) if not, what is the value of x when the hands are together? (c) does not this prove that a fraction of the series $\frac{1}{2}, \frac{1}{2^2}, \frac{1}{2^3}, \frac{1}{2^4}$, etc. will finally be equal to zero, if the series is carried out infinitely? and (d) is it not true that $\frac{1}{3} - \frac{3}{10} - \frac{3}{10^2} - \frac{3}{10^3} - \text{etc.}$, if carried on infinitely, is exactly equal to zero?

This is a very curious paradox and it is of great historic interest. Paradoxes of this nature, which involve the use of infinite series, were first proposed by certain Greek philosophers belonging to what is called the *Eleatic School*. Zeno, of Elea (born about 490 B. C.), one of the most famous members of the Eleatic School, argued against the reality of motion by a subtle paradox, professing to prove that the swiftest animal could never catch the slowest, if the latter had any start. For, suppose, he says, that Achilles pursues a tortoise which has 100 yards start, and suppose that Achilles runs 10 times as fast as the tortoise. It is evident, then, that when Achilles has run 100 yards, the tortoise is still 10 yards in front of him; when Achilles has run these 10 yards, the tortoise is 1 yard in front; when Achilles has run this 1 yard, the tortoise is $\frac{1}{10}$ of a yard in front. After $(n+2)$ of these stages, Achilles would be $\frac{1}{10^n}$ of a yard behind the tortoise; by making n large enough, we can make $\frac{1}{10^n}$ as small as we please, but no matter how large n may be, provided it is finite, $\frac{1}{10^n}$ is not exactly equal to zero. Hence, after $(n+2)$ of these stages, no matter how great the number n may be, Achilles is still behind the tortoise. In other words, say Zeno and the Eleatic School, $\frac{1}{10^n}$ can *never* be equal to zero, and therefore Achilles can *never* overtake the tortoise.

Our readers will notice the similarity between Zeno's famous paradox and our subscriber's question about the hands of the clock. It will also be noticed that in the statement of Zeno's conclusion, the word *never* is printed in italics, in order to draw particular attention to this word; for the whole difficulty arises from the improper use

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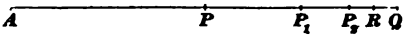
of this word. About the thing itself there is no difficulty or doubt; and by careful attention to what actually occurs, it is easy to avoid being entangled in useless quibbles about words. To explode Zeno's contention that there is no such thing as motion, Diogenes the Cynic, without a word, simply walked across the floor.

These paradoxes taught the Greeks to look with suspicion on the use of infinite series, and led to the invention of what is known as the method of exhaustions, and thus had a very important influence on Greek mathematics.

The development of metaphysics also was affected very considerably by this paradox of Zeno. The word *metaphysics* owes its origin to Aristotle, one of the greatest of the Greek philosophers. After Aristotle had written his work on Physics, he wrote another work, which he called Metaphysics (after the physics), simply because it was written after his Physics. In his reply to Zeno's paradox, Aristotle gave the following definition of *continuity:* "A thing is *continuous* (συνεχες) when of any two of its successive parts the limits, at which they meet, are one and the same, and are, as the word implies, held together." Hence, in reply to Zeno he said, motion is not, like counting, a discrete operation—a series of jerks; the moved thing does not stop at the stages which the calculator chooses to make; a line is not made up of points, nor is a period of time made up of a series of indivisible instants, or "nows." This is, in brief, the answer given by the father of metaphysics to Zeno's paradox.

While Aristotle's explanation may be quite satisfactory to the metaphysicians, we shall endeavor to present the matter in a way that will be more easily understood by ordinary men.

Let the line AQ be 2 inches long; let AQ be bisected in P; let PQ be bisected



in P_1; and so on. Suppose that a particle starts from A and moves toward Q. Suppose the particle to move in such a manner that it passes over 1 inch in an interval of time t; then, over $\frac{1}{2}$ of an inch in the time t_1; then, over $\frac{1}{2^2}$ of an inch in the time t_2; and so on. Under these circumstances, at the end of the interval t, the particle is at P; at the end of the interval t_1, the particle is at P_1; and at the end of the interval t_n the particle is at P_n. Let S_n denote the whole distance passed over by the particle in the $(n+1)$ intervals of time $t, t_1, t_2, \ldots t_n$; and let T_n denote the sum of these intervals.

Then, we have

$$S_n = 1 + \frac{1}{2} + \frac{1}{2^2} + \ldots + \frac{1}{2^n}; \qquad (2)$$

and

$$T_n = t + t_1 + t_2 + \ldots + t_n. \qquad (3)$$

The second member of equation (2) is a geometrical progression, and by elementary algebra, we have

$$S_n = \frac{1 - \frac{1}{2^{n+1}}}{1 - \frac{1}{2}};$$

or,

$$S_n = 2 - \frac{1}{2^n}. \qquad (4)$$

The greater the number n is, the smaller does the fraction $\frac{1}{2^n}$ become; and, by taking n great enough, we can make $\frac{1}{2^n}$ as small as we please, and, consequently, we can make P_nQ as small as we please. But no matter how great n may be, provided it is finite, the fraction $\frac{1}{2^n}$ can *not* be equal to zero. Notice that in this last sentence the word *not* is printed in italics; a great many modern writers on mathematics would write, "but no matter how great n may be, the fraction $\frac{1}{2^n}$ can *never* be equal to zero." It is this substitution of *never* for *not* that creates all the confusion. The word *never* has reference to time. If we are simply considering the values of the fractions $\frac{1}{2}, \frac{1}{2^2}, \frac{1}{2^3}, \frac{1}{2^4}$, etc., the value of each of these fractions is the same now as it was in the days of Aristotle, and the same as it will be at the end of the twentieth century; the words present and future, *now* and *never* have nothing to do with the value of such a fraction as $\frac{1}{2}$ or $\frac{1}{2^2}$. Therefore, if we are to consider *time* in connection with the value of the fraction $\frac{1}{2^n}$, which appears in equation (4), we can do so only by reference to equation (3). Thus, we are entitled to say that at the end of the time T_n, where n is finite, the distance S_n is not equal to 2 inches, but is less than 2 inches by $\frac{1}{2^n}$ of an inch, but this is not the same as saying that S_n can *never* be equal to

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2 inches, unless indeed the interval of time that lies between the beginning of the motion and that epoch of time which we glibly speak of as *never* can be an exceedingly short period. Suppose, for example, that $t = 1$ second, $t_1 = \frac{1}{3}$ of a second, $t_2 = \frac{1}{3^2}$ of a second, $t_3 = \frac{1}{3^3}$ of a second, etc.; then equation (3) becomes,

$$T_n = 1 + \frac{1}{3} + \frac{1}{3^2} + \ldots \frac{1}{3^n};$$

whence,

$$T_n = \frac{1 - \frac{1}{3^{n+1}}}{1 - \frac{1}{3}} = \frac{1}{2}\left(3 - \frac{1}{3^n}\right);$$

or,

$$T_n = 1\tfrac{1}{2} - \frac{1}{2 \times 3^n}. \qquad (5)$$

No matter how great n may be, provided it is finite, the time T_n is less than $1\frac{1}{2}$ seconds. By making n large enough, we can make the fraction $\frac{1}{2 \times 3^n}$ as small as we please, and therefore we can make T_n as nearly equal to $1\frac{1}{2}$ seconds as we please; and, as we have already seen, the variable distance $P_n Q$, which separates the particle from Q, can also be made as small as we please by making n large enough. If the particle never reaches Q, it must stop at some point R between P and Q; then, the distance $R Q$ is a fixed or constant magnitude. But we have seen that the variable distance $P_n Q$ can be made as small as we please; therefore, we can make $P_n Q$ less than the fixed distance $R Q$; that is, the particle which is supposed to stop at R moves past R. Hence, it must be wrong to suppose that the particle stops at any point R between P and Q. In other words, the particle actually reaches Q, and it reaches Q in exactly $1\frac{1}{2}$ seconds, and comes to rest at Q. But we must remember the number of the intervals t, t_1, t_2, etc. required for the particle to reach Q is *not finite.*

In the preceding discussion, we supposed the particle to move with increasing velocity as it advanced from A toward Q. Let us now consider a case in which the particle moves with decreasing velocity from A toward Q; this will be the case if each of the intervals of time is equal to 1 second; so that $t = t_1 = t_2 = t_3 =$ etc. $= 1$ second. The distance passed over in n intervals of time is still given by equation (4), but the time T_n is not, in this case, given by equation (5). Instead, we have

$$T_n = t + t_1 + t_2 + \ldots + t_n;$$

or,

$$T_n = 1 + 1 + 1 + \ldots + 1;$$

whence,

$$T_n = n + 1. \qquad (6)$$

In this case, when n increases without limit, the distance S_n, as given by equation (4), approaches more and more nearly to 2 inches, and by making n large enough, the distance S_n can be made to differ from 2 inches as little as we please; but as n increases without limit, the time T_n, as given by equation (6), also increases without limit. So long as the time T_n is finite, S_n cannot be exactly equal to 2 inches, and the particle cannot quite reach the point Q. In this case, therefore, the particle does not arrive at Q in any finite time.

In both of the cases discussed, the distance passed over in $(n + 1)$ of the intervals of time, provided $(n + 1)$ is finite, is expressed by the sum of $(n + 1)$ terms of the geometrical progression $1 + \frac{1}{2} + \frac{1}{2^2} +$ etc. Manifestly, it would be convenient if we could say that the distance passed over in an infinite number of the intervals is expressed by the *sum of an infinite number of terms* of the same progression. But before we can make this statement we must explain what the sum of an infinite number of terms means.

The ordinary arithmetical definition of addition explains what is meant by the sum of any finite number of terms, but gives no explanation of the sum of an infinite number of terms. In framing a definition of the sum of an infinite number of terms, we must make the new definition, as far as possible, in harmony with the ordinary arithmetical definition, merely introducing into the arithmetical definition whatever modifications may be necessary. Now the sum of a finite number of terms does not, in any way, depend upon the element of time; therefore the new definition must not contain such words as *ever* and *never*, which involve the idea of time. The following definition fulfils these conditions:

DEFINITION.—*If a series of terms, formed in a definite order according to a fixed law, is such that the sum of n of its terms taken in order, by increasing n, can be made to differ from a constant finite number S by an amount less than any assignable quantity, then S is called the sum of an infinite number of terms of the series, and the series is said to be convergent.*

Some authorities would further restrict this

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definition by including in it the statement that the sum of any finite number of its terms cannot be equal to S. This restricting statement is inadmissible, because there are convergent series in which the sum of a few terms is equal to the sum of an infinite number of terms.

In accordance with the definition given above, the sum of an infinite number of terms of the geometrical progression in the second member of equation (2) is $S = 2$; and the sum of an infinite number of terms of the geometrical progression $a + ar + ar^2 + ar^3 +$ etc., is $S = a + ar + ar^2 + ar^3 +$ to infinity $= \frac{a}{1-r}$, provided r is numerically less than unity.

The ordinary arithmetical definition of multiplication explains what the continued product of any finite number of factors is, but does not fix the meaning to be attached to the continued product of an infinite number of factors. Hence, if we are to speak of the continued product of an infinite number of factors, we must frame some such definition as the following:

DEFINITION.—*If a continued product of factors, formed in a definite order according to a fixed law, is such that the product of n of the factors taken in order, by increasing n, can be made to differ from a constant finite number P by an amount less than any assignable quantity, then P is called the product of an infinite number of the factors.*

Now, $\frac{1}{2^n}$ is the continued product of n factors, each equal to $\frac{1}{2}$; and, evidently $\frac{1}{2^n}$ can be made to differ from zero by an amount less than any assignable quantity by taking n large enough; therefore, by the preceding definition, $\frac{1}{2^n}$ is equal to zero if n is infinite.

Let us now return to Achilles and the tortoise. Suppose that the tortoise runs at a uniform rate of 1 yard in $\frac{1}{10}$ of a minute; then, Achilles runs 10 yards in $\frac{1}{10}$ of a minute. Therefore, Achilles gains 90 yards on the tortoise in 1 minute. Dividing the chase into stages, as Zeno did, we find that the first stage lasts 1 minute, and Achilles gains 90 yards; the second stage lasts $\frac{1}{10}$ of a minute, and Achilles gains 9 yards; the third stage lasts $\frac{1}{10^2}$ of a minute, and Achilles gains $\frac{9}{10}$ of a yard, and so on. Let S_n denote the distance Achilles gains in $(n+1)$ stages, and let T_n denote the time occupied by these stages.

Then, we have

$$S_n = 90 + 9 + \frac{9}{10} + \ldots + \frac{9}{10^n}; \qquad (7)$$

and

$$T_n = 1 + \frac{1}{10} + \frac{1}{10^2} + \ldots + \frac{1}{10^n}. \qquad (8)$$

According to the definition of the sum of an infinite number of terms, the sum of an infinite number of terms of the geometrical progression in the second member of equation (7) is

$$S = \frac{90}{1-\frac{1}{10}} = \frac{900}{9} = 100,$$

and the sum of an infinite number of terms of the geometrical progression in second member of equation (8) is

$$T = \frac{1}{1-\frac{1}{10}} = \frac{10}{9} = 1\tfrac{1}{9}.$$

Thus, Achilles gains 100 yards, and overtakes the tortoise in an infinite number of intervals of time, and the sum of all these intervals is equal to $1\frac{1}{9}$ minutes. At any instant before the lapse of $1\frac{1}{9}$ minutes, Achilles is behind the tortoise; at the end of $1\frac{1}{9}$ minutes he has exactly overtaken the tortoise; and at any later instant Achilles, if he does not stop, is ahead of the tortoise. Then, we reply to Zeno that if the tortoise and Achilles run with uniform velocity, the time may be divided into an infinite number of parts, as he says; but these parts decrease in geometrical progression, and the sum of an infinite number of them is equal to a finite interval of time.

But, suppose that Achilles and the tortoise, instead of running with uniform velocities, become leg-weary and run with decreasing velocities. Suppose the tortoise runs the first 10 yards in 1 minute, runs the next yard in 1 minute, the next $\frac{1}{10}$ of a yard in 1 minute, and so on. Then Achilles runs his first 100 yards in 1 minute, the next 10 yards in 1 minute, the next yard in 1 minute, and so on. In this case, Achilles gains 90 yards in the first minute, 9 yards in the second minute, $\frac{9}{10}$ of a yard in the third minute, and so on. Hence, the distance gained by Achilles in $(n+1)$ of these intervals of time (minutes) is given, as before, by equation (7). But in this case the sum of the $(n+1)$ intervals of time is given by the equation

$$T_n = 1 + 1 + 1 + 1 = n + 1,$$

or

$$T_n = n + 1, \qquad (9)$$

instead of being given by equation (8). When n is infinite, as in the former case, the distance gained by Achilles in an infinite number of intervals of time is

$$S = 90 + 9 + \frac{9}{10} + \ldots \text{ to infinity},$$

or

$$S = 100.$$

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But in this case the intervals of time are all equal, and the sum of them is an infinite period of time. In this case, therefore, it takes an infinite time for Achilles to overtake the tortoise; in other words, Achilles does not overtake the tortoise in any finite time, which means that he never overtakes it.

From this discussion, it appears that the question of whether Achilles overtakes the tortoise or not depends neither upon fine metaphysical distinctions nor upon subtile quibbles about words, but simply upon whether he runs fast enough or not. If he runs fast enough he will overtake it soon; if he runs slow enough, there will be a good deal of eternity fooled away before the tortoise is overtaken.

If we merely desired to determine when Achilles overtakes the tortoise, we would solve the problem in a different and simpler way; but it was necessary to discuss the question in the manner given above, in order to meet the Eleatic School upon their own ground.

In the clock problem we could easily follow out the same lines of discussion as given above for the Achilles paradox, and we would show that the minute hand overtakes the hour hand at exactly $5\frac{5}{11}$ minutes past one o'clock, and then the minute hand passes the hour hand. It is easier, however, to say that in 1 minute of time the minute hand moves 1 minute space, and the hour hand moves $\frac{1}{12}$ of 1 minute space; hence, in 1 minute of time the minute hand gains $1 - \frac{1}{12}$, or $\frac{11}{12}$ of a minute space. Therefore, it takes the minute hand $5 \div \frac{11}{12}$, or $5\frac{5}{11}$ minutes to overtake the hour hand. This answers questions (a) and (b). With regard to question (c), we have already stated that the fraction $\frac{1}{2^n}$ is, by definition, equal to zero when n is infinite. In accordance with the definition of the sum of an infinite series, we give an affirmative answer to question (d) also.

There is a familiar problem in theoretical mechanics that involves the same considerations. At a place where the acceleration due to gravity is 32.16 feet per second per second, an imperfectly elastic particle is projected vertically upward from a point in a horizontal plane with a velocity of 32.16 feet per second; when it falls upon the plane it continually rebounds and rises to $\frac{1}{2}$ of the height from which it fell. Neglecting the time occupied by the series of impacts and the resistance of the air, find the whole distance through which the particle moves and the time that elapses before it is brought to rest. It is shown in elementary books on dynamics that the whole distance through which the particle moves is given by the equation

$$S = \frac{v^2}{g}(1 + e + e^2 + \text{to infinity});$$

or,
$$S = \frac{v^2}{g} \times \frac{1}{1 - e^2}; \qquad (10)$$

and the time that elapses before the particle comes to rest is given by the equation

$$T = \frac{2v}{g}(1 + e + e^2 + \text{to infinity});$$

or,
$$T = \frac{2v}{g} \times \frac{1}{1 - e}, \qquad (11)$$

where v = velocity of projection in feet per second = 32.16;
g = acceleration due to gravity = 32.16;
e = coefficient of restitution = $\frac{1}{2}$.

Substituting these values in equations (10) and (11), we get $S = 42.88$ feet, and $T = 4$ seconds. This particle makes an infinite number of rebounds in the space of 4 seconds.

To prevent misconceptions, it may be well to repeat that the fraction $\frac{1}{2^n}$ is not equal to zero, no matter how great a finite number n may be; for example, when n is equal to the millionth power of a million, $\frac{1}{2^n}$ is not equal to zero. Furthermore, we did not prove that $\frac{1}{2^n}$ is zero if n is infinite; we merely laid down the definition that $\frac{1}{2^n}$ is zero if n is infinite.

This is a free country; and any able-bodied American citizen, of full age, who is neither a criminal, confined in a house of correction, nor a pauper in receipt of public alms, is at perfect liberty to reject one or both of the definitions given in this article. If he rejects these definitions, he should either abstain from using the sum of an infinite number of terms and the product of an infinite number of factors, or frame some definitions to take the place of those we have given. Whatever he may do with regard to these definitions, it is to be hoped that he will not permit any cunning combination of words, or any jugglery with algebraic symbols to obscure his vision so that he cannot tell the time of day by a clock, and has skeptical doubts as to whether the minute hand will ever overtake the hour hand.

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UNDERPINNING

Owen B. Maginnis

THE CONDITIONS REQUIRING THE UNDERPINNING OF WALLS—THE PRINCIPAL METHODS EMPLOYED—THEIR CONSTRUCTION AND ADVANTAGES

IT OFTEN happens that the foundation of a new building is to be constructed close to an adjoining structure, the footings of which have not been carried down to the depth that is required for the new building. If the soil or bottom upon which the existing building rests is soft clay and sand, gravel, loose sand, or in fact any soft soil that would be liable to compress, crush, or subside when the excavations for the new building are proceeding, then proper precautions must be taken to preserve the old or existing building from injury and prevent it from suddenly settling and thus causing the walls to fracture or collapse.

Such a condition of affairs is shown in Fig. 1. In this case the bottom of the excavation for the new building is 10 feet below the curb line, while the footing of the old building is only 4 feet from the curb line. From this figure it can readily be seen that the wall of the old building would crush the earth underneath its footings after the excavation for the new foundation had been made. To avoid such a disaster, builders and house shorers place temporary supports underneath the walls of the old building, so that they will be safely carried until a new foundation can be built. The purpose of such shores is usually to support the old wall until the new foundation can be built from the bottom of the excavation up to the old footings.

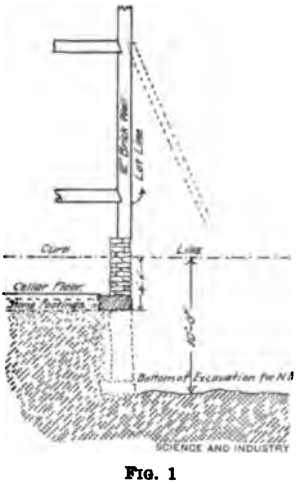

FIG. 1

This question of underpinning is one that is of great interest to architects and owners, for many important legal cases have had their origin in a plea for damages instituted by owners whose buildings were ruined by carelessness in excavating for the foundations of adjacent buildings. In large cities the importance of protecting existing structures from damage caused by adjacent building operations became evident to the lawmakers, and laws and ordinances governing such cases were drawn up and adopted, and in most cases rigorously enforced. The following quotation from the complete laws of New York will show conclusively the extent and purpose of such an ordinance, and show to the reader how important it is to provide adequate methods of underpinning.

EXCAVATIONS AND FOUNDATIONS

Sec. 22. *Excavations.*—All excavations for buildings shall be properly guarded and protected so as to prevent the same from becoming dangerous to life or limb and shall be sheath-piled where necessary to prevent the adjoining earth from caving in, by the person or persons causing the excavations to be made. Plans filed in the Department of Buildings shall be accompanied by a statement of the character of the soil at the level of the footings.

Whenever an excavation of either earth or rock for building or other purposes shall be intended to be, or shall be carried to the depth of more than ten feet below the curb, the person or persons causing such excavation to be made shall at all times, from the commencement until the completion thereof, if afforded the necessary license to enter upon the adjoining land, and not otherwise, at his or their own expense preserve any adjoining or contiguous wall or walls, structure or structures from injury, and support the same by proper foundations, so that the said wall or walls, structure or structures, shall be and remain practically as safe as before such excavation was commenced, whether the said adjoining or contiguous wall or walls, structure or structures, are down more or less than ten feet below the curb. If the necessary license is not accorded to the person or persons making such excavation, then it shall be the duty of the owner refusing to grant such license to make the adjoining or contiguous wall or walls, structure or structures, safe, and support the same by proper foundations so that adjoining excavations may be made, and shall be permitted to enter upon the premises where such excavation is being made for that purpose, when necessary. If such excavation shall not be intended to be, or shall not be, carried to a depth of more than ten feet below the curb, the owner or owners of such adjoining or contiguous wall or walls, structure or structures, shall preserve the same from injury, and so support the same by proper foundations that it or they shall be and remain practically as safe as before such excavation was commenced, and shall be permitted to enter upon the premises where such

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excavation is being made for that purpose, when necessary.

In case an adjoining party wall is intended to be used by the person or persons causing the excavation to be made, and such party wall is in good condition and sufficient for the uses of the adjoining building, then and in such case the person or persons causing

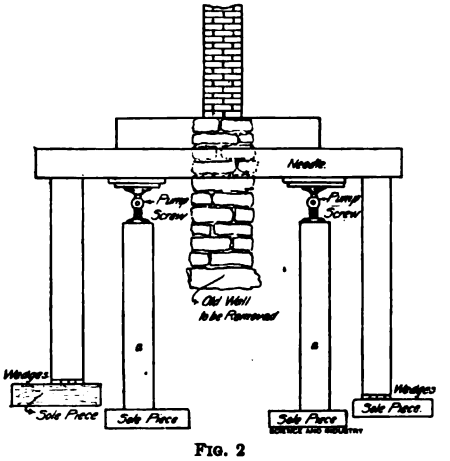

FIG. 2

the excavations to be made shall, at his or their own expense, preserve such party wall from injury and support the same by proper foundations, so that said party wall shall be and remain practically as safe as before the excavation was commenced.

If the person or persons whose duty it shall be to preserve or protect any wall or walls, structure or structures, from injury shall neglect or fail so to do, after having had a notice of twenty-four hours from the Department of Buildings, then the Commissioner of Buildings may enter upon the premises and employ such labor, and furnish such materials, and take such steps as, in his judgment, may be necessary to make the same safe and secure, or to prevent the same from becoming unsafe or dangerous, at the expense of the person or persons whose duty it is to keep the same safe and secure. Any party doing the said work, or any part thereof, under and by direction of the said Department of Buildings, may bring and maintain an action against the person or persons last herein referred to, to recover the value of the work done and material furnished in and about the said premises in the same manner as if he had been employed to do the said work by the said person or persons. When an excavation is made on any lot, the person or persons causing such excavation to be made shall build, at his or their own cost and expense, a retaining wall to support the adjoining earth; and such retaining wall shall be carried to the height of the adjoining earth, and be properly protected by coping. The thickness of a retaining wall at its base shall be in no case less than one-fourth of its height.

When the excavation for a new building is being executed it is the duty of the contractor or his foreman to stop the excavation at the bottom of the stone or concrete footings of any or all contiguous buildings, and the excavation should not be allowed to proceed until the foundation walls and footings of buildings that are liable to damage have been properly and thoroughly protected, either by temporary shoring, needling, or by thorough underpinning. The best way to protect the foundations of a building having solidly-built walls and where the footings are some distance above the bottom of the excavation, is to insert timber needles through the wall, either under the base stone or the concrete footings. If the walls are to be underpinned with a continuous stone or brick underpinning, they may be needled under the superimposed brickwork at the top of the stone foundation work, as shown in Fig. 2. In this figure the needle is reenforced or stiffened by a second timber placed on its upper side, to prevent sagging under the weight of the wall. The shores or uprights are likewise often doubled, in order to guard against any settlement at the sole pieces, or plates. In such a case two sets of uprights are used, one set having pump screws and the other being provided with wedges so that should settlement take place in the inner shores, or those marked

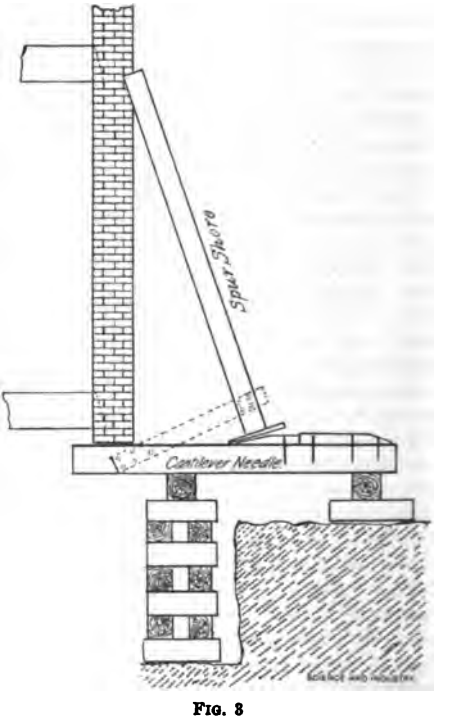

FIG. 3

a, a in Fig. 2, the wedges under the outside ones can be driven up tight, thus relieving the inner shores of much of the weight. The needles and shores should be kept from 6 to 8 feet apart and set level and plumb,

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likewise solid. When sufficient needles are inserted in the manner described, the wall will corbel or arch itself between them, and the intervening stonework may be removed, the new foundation wall being built up

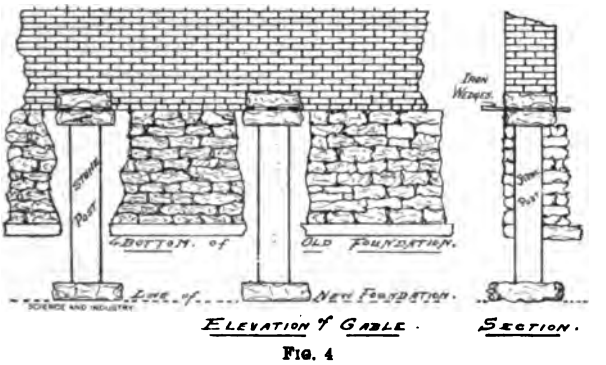

FIG. 4

from the bottom of the excavation, as shown by the dotted lines in Fig. 1. Should the wall that is supported upon needles show any indications of buckling or bulging, raking or spur shores may be placed at the second- or third-story tier of beams. These props will steady the wall and prevent any danger of collapse.

The illustration of Fig. 3 shows a very good method of combining blocking, needling, and shoring for the purpose of underpinning the wall without encroaching upon the built and occupied premises. In this figure the cantilever or needle is a strong $12'' \times 12''$ oak or yellow-pine timber, resting upon the blocking which is placed upon the firm bottom of a trench or hole dug to the same level as the new adjoining excavation. The blocking is located at about one-fourth the length of the cantilever or needle beam from its end, the beam being held in equilibrium by the spur or raking shore that has its upper end set in the wall at the second-story tier of floorbeams. The spur or raking shore, besides holding the needle beam in equilibrium, also prevents the wall from bulging. The bottom end of the shore is prevented from slipping by the heavy oak blocks and wedges shown in Fig. 3. For further security against slipping, stout 2-inch braces or ties are often nailed or spiked to each side of the brace or needle.

Many contractors follow the method of underpinning illustrated in Fig. 4, and where this is employed no shoring or needling need be used, since the wall is supported directly from the bottom of the adjoining excavation on granite or iron posts. These posts or supports are inserted in rises, or chases, cut out of the old wall to admit them. This can safely be done, as the brickwork corbels or arches itself between the inserted supports. Where such methods of procedure are employed, the posts are set on station bases of sufficient area and capped with two bluestone plates or station templets, the wall being brought to a bearing upon the posts by driving wrought-iron wedges between the templets until the maul rebounds and they cannot be driven any farther. The templets must in all cases be bedded in good strong Portland cement mortar before being wedged up tightly. The writer has seen many gable walls safely underpinned by this method, and remembers that in one case the posts used were old front first-story columns that had only supported a granite lintel in the old-fashioned way still to be seen in many existing buildings constructed previous to the extensive introduction of cast-iron columns. When

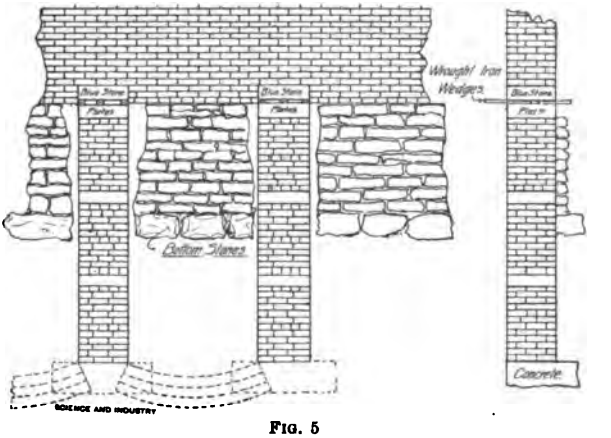

FIG. 5

the excavation is carried down to a great depth, it is necessary to use brick piers with mortar instead of granite or cast-iron posts, and when such piers are used care must be taken to see that they have sufficient

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sectional area to fully support the loads coming upon them from the building.

Fig. 5 shows the method of underpinning by use of brick piers well bonded. In this case the bottom of the excavation for the new building is so far below the old footings that the rough rubble wall forming the old foundation had better be removed and the sides between the piers filled in with a light retaining wall of stone or brick. Should the bottom of the excavation for the piers prove to be of soft earth, it may be necessary to distribute the weight of the building by footings consisting of grillage, ranging timbers, or inverted arches. Where such a condition exists, the special foundation should be put in place before the piers are built in, and such shoring and needling as will be necessary should be provided. It can readily be seen that such foundations, and especially the inverted arches, could not be safely built without first supporting the old work above. The dotted lines in Fig. 5 show the inverted arches and also the concrete footing. Before the wedges between the templets on the top of the brick piers are driven tight, the mortar in the piers must be given ample time to set, in order that full strength of the brickwork may be realized before they are subjected to the weight from above. It is a good practice, and a precaution that should never be neglected, to lower the shoring under needling very gradually, so that no sudden shock will come upon the new work.

FIG. 6

Fig. 6 illustrates clearly the method by which a girder may be supported upon a grillage of heavy timbers laid across each other at right angles. If the blocks are available and of regular sizes, this method is safer and more reliable than vertical shores supporting horizontal needles, because, on account of the increased area of the base, there is less lateral movement. It is really the only method to employ where the entire story is to be removed in order to make alterations, but it has the disadvantage of taking up space and requiring considerable material in the way of timber.

In conclusion, the writer would impress upon all those engaged in the practice of architecture or building operations the importance of observing every precaution for the preservation of foundations supporting the adjacent buildings. The careful consideration of this subject is of preeminent importance at the beginning of the twentieth century, when buildings of great height and weight are often erected adjacent to or between low and light buildings, and should there be no proper precaution taken, it is not only possible but highly probable that the result will be disastrous, for the heavy masses of the greater structure will drag down and injure the smaller one. This is especially the case where the composition of the earth under the footing is of a compressible nature. The proper consideration of foundations and footings has never required more skill and care in the history of building construction than it does now, and should never for any reason be neglected.

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STREET-CAR WIRING

Eug. C. Parham

SIZES OF WIRE—GROUPING—RUNNING WIRE IN SINGLE HOSE, IN TWO HOSE, AND IN THREE HOSE—DISADVANTAGES OF EACH METHOD

MANY a reader, perhaps, whose eye chances to fall on the title of this article, will have a general idea of what it is to wire a car, and may wonder what there is to it that can be profitably written about. Any of these readers who will take the trouble to step into a depot or street-car repair shop immediately after a heavy thunder shower or snow storm, and see a few of the troubles to which motor equipments fall heir, and which keep the barn men on a continuous jump while the trouble lasts, will be in a position to agree with us that a little talk about some of these troubles and their causes and cures will do no one any harm.

The talk is addressed more particularly to those who know very little about the under side of a car, so that the battle-scarred expert may save himself some little time by reading on a line more conducive to his advancement; but if he should risk the attempt, it is to be hoped that he may cull a point here and there at least presented to him in a little different light from what he has been accustomed to see it.

As a rule, the equipment shipped to any given road is wired according to a blueprint provided by the makers, who know very well the traffic conditions to be met with and the size of the motors to be used. The blueprint is always marked "Car-Wiring Diagram for 2 —— horsepower motors and 2 controllers," and it further specifies the size of each wire to be used in connecting the motors to the several controlling devices on and under the car. If the car is wired according to such a blueprint, and for the motors and other devices that the print calls for, the job, when done, cannot be very far wrong, at least in regard to the sizes of wires used and the path of the current through the various devices and connections. But it is very often the case that there are several sizes of motors on the same road, and just as often the thoughtless practice to indiscriminately shift motors from one car to another, without any regard whatever to the question as to whether or not the hose and its 500 or 600 feet of wire will do the work in a satisfactory and economical manner. Of course, it is safe, as far as the wires are concerned, to put a pair of small motors where a pair of large motors have been, but it is by no means safe to subject the car wires proportioned to transmit the power of the small motors, to the duties of a hose adapted to use with larger motors.

Let us see now what some of the factors are that dictate the size that the wires in a car hose shall be. In the first place, the wires must be large enough to carry the car's current without any danger from excessive heating; in the second place, this current must be carried without excessive loss in voltage due to the resistance of the wire itself and that of its joints and connections. To consider the last item first, let us take a 20-foot box car, equipped with two 30-horsepower motors and two K-11 G. E. controllers. The controllers call for 14 wires running from one of the car motors to the other; on a 20-foot box car, each wire will be about 30 feet long, so that when the motors are in series the current must pass through about 500 feet of wire, including the motor taps and the trunk wire. Each motor can be considered to have its own section of the wiring; when the motors are in series, the two sections of wiring are in series and when the motors are in multiple so are their respective sections, and each section 250 feet long takes but half of the total current that runs the car. A 30-horsepower motor at full load calls for a current of $\frac{30 \times 746}{500} = 45$ amperes, in round numbers, if the line voltage is assumed to be 500 volts. The two motors at full load, then, would cause a current demand of 90 amperes. Assuming the car wires to be No. 6 B. & S. gauge, the size formerly used for 30-horsepower motors, the resistance of the car wires with the motors in series will be .2 ohm, as 1,000 feet of No. 6 B. & S. copper wire measures .4 ohm, and the resistance in multiple is $.2 \div 4 = .05$ of an ohm. This, with a current of 90 amperes, would cause a drop of $90 \times .05 = 4.5$ volts. This added to the drop that takes place through the connectors, the internal controller wires, and the finger contacts, will bring the total loss up to

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7 volts, which is not excessive. A No. 6 B. & S. wire under the conditions will carry a current of 45 amperes ($\frac{9}{4}^{0}$) with an increase in the temperature of about 10.5° C., while a No. 7 B. & S. wire would cause a rise in temperature of about 20° C., almost twice as much. The No. 6 B. & S. wire is the smallest size that it would be good policy to use on a 30 horsepower equipment, as the field leads on the 30-horsepower motors are generally of that size, and it would not be well to have an enclosed wire smaller than an open one, and thereby, in case of a short circuit, have the closed one, which is not easy of access, give way first. Now suppose 60-horsepower motors to take the place of 30-horsepower motors, the wiring remaining the same.

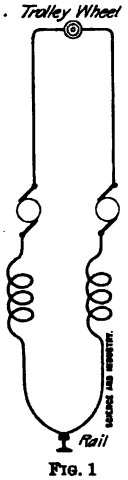

FIG. 1

A 60-horsepower motor, at a voltage of 500, calls for a current of $\frac{60 \times 746}{500} = 90$ amperes, in round numbers, or 180 amperes per car; 180 amperes flowing through a resistance of .05 ohm will give a drop of $180 \times .05 = 9$ volts, which, added to the drop of 5 volts due to contacts and connections and twice as great as before, brings the total drop up to 14 volts, which is about $\frac{1}{4}$ of the total drop allowed in the overhead feed-wires and rail return. Also, a current of 90 amperes flowing through a No. 6 B. & S. wire under the conditions given would cause a temperature rise of about 50° C., which is as much of a rise as is often allowed in the motors themselves, and is prohibitive; also this increase in temperature raises the resistance of the wires and further increases the voltage drop through them.

The above talk has been based on the assumption that there is a straight double circuit through the two motors from the trolley wire to the ground, as indicated in Fig. 1, where, as a matter of fact, in part of the circuit, represented by the trunk trolley and ground wires shown at *A B* and *C D*, respectively, in Fig. 2, a single wire is compelled to carry the total current. This small error of assumption affects the actual results of calculation very little, and does not affect the principle under discussion at all. It does, however, have this much practical bearing on the wiring of a car: since the individual motor wires are called upon to carry but $\frac{1}{2}$ of the total current of the car, while the trunk wire must at all times carry all of the current of both motors, the trunk wire should always have a cross-section twice that of the motor wire. On a 60-horsepower car equipment (two 30-horsepower motors) where a No. 6 B. & S. wire is used for the motors, the trolley and ground wires should be No. 3 B. & S. stranded cable. On a 120-horsepower car (two 60-horsepower motors) using No. 4 B. & S. motor wires, the trunk wiring should all be No. 0 B. & S. stranded cable. There is no cast-iron law against using a larger size of wire than the size given, and there might indeed be extreme conditions where a larger size of wire would be desirable; but for average conditions, and these are by no means assumed to be light, there is a large factor of safety provided for in recommending No. 3 B. & S. and No. 6 B. & S. wire for a 60-horsepower car; and No. 0 B. & S. and No. 3 B. & S. for a 120-horsepower car, so that if there happens to be on hand a lot of wire approximating these sizes it would be safe to use it as a saving in copper, but its adoption as a standard would not be recommended. It is the prevailing practice among street-railway men, following the example set by the manufacturers, to make the resistance wires in a car-wiring hose of a smaller size than that used on the motors, thereby introducing a third size of wire to be kept in stock. This practice is not born of the idea that the current flow is less on the first notches than it is on the more advanced ones, for it is a well known fact that one of the properties of a series motor (a street-railway motor is a series motor) is that for a given mechanical load to be pulled under conditions that do not change, the current remains almost the same whatever may be the voltage applied to the motor. When the motors are thrown over from series to parallel, the current taken by the car, of course, increases, because there are two paths instead of one, but since the wires too are in multiple, each section takes only half the total current. The result is that on modern equipments where the resistance of the starting coil is low and the starting current large, the resistance wires are subjected to as heavy a current as any

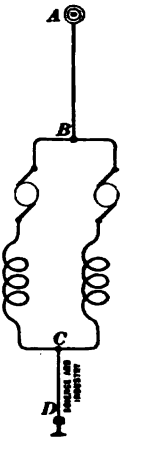

FIG. 2

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of the motor wires. It is true that as long as some of the starting coil is in the circuit, the resistance of the small wires is no offense to economy, because the resistance is just where it is wanted; also, since the resistance notches are merely transition notches, and are not to be run on, a smaller wire in the resistance circuit will not, if the car is well handled, give any trouble from excessive heating, because they are not left in long enough. Again, making the resistance wires smaller, enables them to be more easily distinguished from the rest of the wires, and thus facilitates connecting at the controllers; but this feature is obtained in a better way, as will be seen later.

There is one condition that all level-headed railroad men are striving to establish on their roads, and this is a condition for the realization of which a great many sacrifices can be profitably made: a condition of standardization; that is, where there is any possible chance of making two parts or members *alike*, without actually throwing a bombshell in the camp of safety or economy, do not make them *different*. It is along these lines and with the idea that every little bit helps, that the writer would recommend sacrificing the electrical refinements hidden in the practice of using three sizes of wire in a hose and come down to the simpler, and in the long run cheaper, practice of making all of the wires the same size, which can be done by running the ground and trolley wires two-in-hand. Think of a hose with only one size of wire in it; only one size to keep in stock, not three sizes. This means, in the first place, that not so much wire need be kept in stock; in the second place that there is not nearly the same chance of running out of wire when it is most needed; and in the third place, that storeroom space, labor, bookkeeping, and perhaps messenger and telegraph service, not to mention worry, are made less. What is true in regard to the wire is true of *everything* that can be standardized, and it is as much at the *everything* that this harangue is directed as at the wire.

In olden times, it was the custom to run the car wires in two lines of canvas hose when a controller was used. In many places this custom is adhered to yet; each motor has its own cable or hose, the trolley and resistance wires going into the hose of the motor that is nearest to the line trolley wire in the natural path of the current from the wire to the rail. The object of this separation of the motor wire was to isolate from each other the wires that were at the greatest difference of potential, presumably, or to permit the use of a smaller size canvas hose. Whatever may have been the reason for doing it, it was along the right lines, but for neither of the reasons given above. Running the two sets of motor wires in the same hose does not subject them to any greater difference of potential, if the ground wire is run outside, than they are exposed to when run in two lines of hose, because as soon as the motors are in full multiple, one side of each motor has a wire direct to the trolley wire and the other side a wire direct to the ground. Only while the motors are in series does the placing of the two sections in a separate hose lessen the difference of potential to which neighboring wires are exposed. In the old system of rheostat wiring, the wires were not put in a hose at

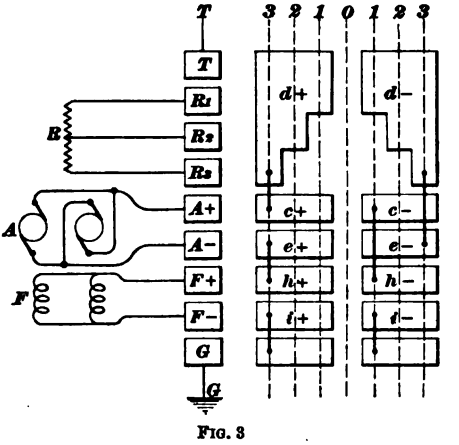

FIG. 3

all, but were just cleated to the under side of the car body direct, or to a wide board fastened to it; the wires not being concealed or protected in any way, were exposed to water, mud, and brine slung by the wheels, and often to the grease and oil thrown by the open gearing. Had this system of wiring been carried out with any pretension of a realization of the necessity of care, neatness, and immunity from the inroads of grease and moisture, it had its advantages. But carelessness and ignorance, together with the fact that rubber-covered wires used at that time were not of the superior grade that is used now, soon opened up a line of experience that condemned the practice, so that when the notch controller and the sectional starting coil came into use, thereby increasing the number of car wires required, the hose protection was adopted.

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This grouping of all of the wires along a common path was rendered more practicable by the fact that the continuity of the path was not broken by the interposition of an independent system of reversing switches, all wires going directly from controller to controller, and communication with the several scattered devices under the car being made by means of taps, as at present. The ground wire was either placed in the hose of one of the motors (the one that did not include the trolley wire) or it was run outside of the hose altogether, being cleated directly to the car floor or to a wooden strip provided for the purpose. The ground wire being already to ground and there being no tendency for it to ground further and therefore no special reason why extra care should be taken to insulate it, there can be no objection to the practice of running it outside of the hose. As a matter of fact, since it is a part of the circuit that seems to be especially susceptible to loose connection and open-circuit troubles, it is advisable to have it outside, where it can be readily inspected by the eye and hand, has its advantages.

With the old rheostatic control, a diagram of which is shown in Fig. 3, very few wires were used, and the paths of these were scattered; with the advent of the ordinary multiple controller (with its several resistance notches) a diagram of one of which is shown in Fig. 4, more wires were called for; while the coming in of the series-parallel controller seemed to promise a multiplicity of wires and an intricacy of circuits to be abhorred. But this fear has not been realized; indeed, with the radical improvement in the quality of the insulation to be found on such rubber-covered wires as are used in car wiring, the quantity of insulation required is not so great, with the result that the diameter of the wire is less and more of them can be got into a hose of a given size.

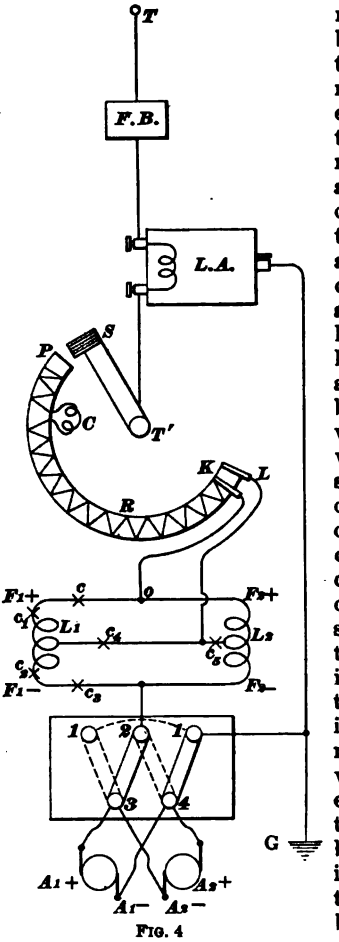

FIG. 4

The final effect of the great increase in insulating quality and decrease in over-all diameter of the wires, has been to create a desire to put all of the wires into a single hose. This can be done on any up-to-date surface car controller without using a hose the size of a sewer, either. The fourteen wires required on the K-11 controller, to be considered later, can be drawn into a 3-inch canvas hose. The grouping of all the car wires into a single hose makes a neat job and it can be made a safe one, as far as the dangers incident to normal conditions are concerned; but there are conditions that are not normal: lightning, loose splices, and abrasion from the wheels of double-truck cars are among them. If all of the wires are in one hose, a mishap to one wire, as a rule, disables all of them, and any one who has worked in a car barn knows that such mishaps are not such rarities that the board of directors meets whenever one occurs. The writer has in mind one instance where, during a thunder shower, 7 out of the 43 cars operated from a certain depot came in for short-circuited or open-circuited cables. To run the wires in separate hose and so group them that with the motors in multiple all wires of about the same potential would be in the same hose, would so mix and criss-cross them, where they come out at the ends to go to the controller, that the connections would become an unsightly and intolerable mess. Nor is there anything to be gained by doing this; all that is called for is to so group the wires as to minimize the chances of a single fault rendering the car helpless. This condition, the writer's experience teaches him, can be fulfilled as follows: Put the trolley wire and all of the resistance wires in one hose, the No. 1 motor wires in another hose, and the No. 2 motor wires together with the ground wire in a third hose. The No. 1 motor is, as a rule, accepted to be the

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motor that the current reaches first in its passage from the trolley wire to the ground, when the two motors are in series. The No. 2 motor is the one next to the ground, and it generally has one of its armature or field leads permanently connected, either to the ground wire or to the motor frame direct. If, however, it is preferred to divide the car wires into two groups only, the trolley wire, the resistance wires, and the No. 1 motor wires go into one hose, while the No. 2 motor wires and the ground wire go into the other. Either of these groupings is less liable to give trouble than a single hose.

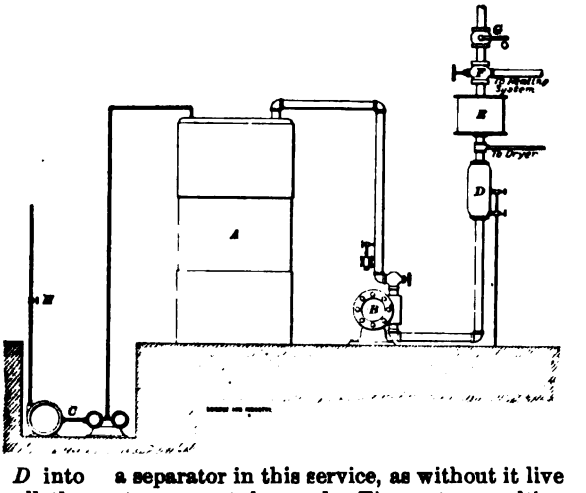
(*To be Continued.*)

AN ECONOMICAL STEAM PLANT

W. H. Wakeman

THE following description of a steam plant that is designed to develop 30 horsepower is given because it contains several points of interest to those that are about to install similar plants, since not only its first cost was moderate, but it can also be operated at small expense. Many plants now in use might be remodeled so as to embody these ideas, with both pleasure and profit to those that run them.

Reference to the illustration will make the arrangement of the several parts plain, and my reasons for this design of plant will be given. *A* represents a vertical boiler, *B* a horizontal engine, *C* a pump and receiver, *D* a separator, *E* a feedwater heater, *F* a cross-valve, *G* a noiseless back-pressure valve, and *H* a cold-water pipe and valve.



Steam generated in the boiler passes over to the engine, which is 10 in. × 10 in., and runs at 200 revolutions per minute. This engine is fitted with an improved sight-feed lubricator, in which only the best of mineral oil is used; 1 pint of oil lasts 40 hours. This is much better than to use a larger quantity of cheaper oil, since the exhaust steam is easily and thoroughly cleansed by the separator *D* into which it passes. This also takes all the water out of the exhaust steam, and the drip pipe shown conducts it to the sewer. Steam is taken out of the tee above the separator for use in a dryer containing a large bank of pipes. A fan forces air rapidly through this dryer in order to make it as effective as possible, since it is almost constantly used to its full capacity in order to dry the output of the factory.

The manufacturers of this drying apparatus claim that it requires live steam at 60 pounds pressure, but in this case the exhaust steam answers very well on account of being perfectly dry, the separator having taken out all of the moisture.

Steam from the same outlet is also used in another apparatus, in which an effort had previously been made to use exhaust steam just as it came from an engine, but it would not answer the purpose, owing to the moisture it contained. Yet, under the present plan, it is perfectly satisfactory. This gives conclusive proof of the value of a separator in this service, as without it live steam must be used. The water resulting from the condensation of steam in all of the above-mentioned apparatus flows back to the receiver *C*, which, for this purpose, is located in a pit 3 feet deep; the pump automatically puts it back into the boiler. It passes through the feedwater heater *E*, for while the feedwater is warm enough to go directly into the boiler, all the exhaust steam is not used in warm weather. Now, as some water and steam escape through the

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drip from the separator, there is always a loss, which must be made good from the street main. The valve and pipe at *H* is provided for this purpose, and as it is located in a convenient place, the engineer admits as much as is required. Since the pump is entirely automatic, its throttle valve is opened wide in the morning and not touched again as long as the engine is running. This plan saves the hot water of condensation, which is pure, and therefore will not make scale in the boiler. At the same time, as water must be bought by meter measurement, it reduces the water bill to a minimum. The cold water reduces the temperature of the hot water of condensation, but the heater raises it again nearly to the boiling point. This heater is much smaller and less expensive than would be required if only cold water were used.

Heating the water condenses some of the steam, and the resulting water flows through a drip pipe into the receiver, so that it is not lost. I wish to call attention to the cross-valve shown at *F*, as it makes a much neater job than the ordinary cast-iron tee, with a globe valve in the pipe leading to the heating system. In this case, the outlet from the cross-valve discharges into a header, out of which steam is taken to heat the factory in cold weather. If there is not enough exhaust steam for this purpose, live steam is admitted to the header through a reducing valve that keeps the pressure nearly constant under all reasonable changes in the amount required to heat the rooms. It makes but little difference whether or not the boiler pressure varies, so long as the engineer is not required to give the matter his attention. Some of the radiators are nearly as low as the floor line of the engine room, hence the further necessity of putting the pump and receiver in a pit, as shown.

As this pit is below the sewer pipe, a small ejector is provided to remove water that collects from drips in the steam cylinders of the duplex pump, etc.

When steam at 2 or 3 pounds is required, as in this case, and only a portion of the exhaust steam is used, the ordinary back-pressure valve becomes an intolerable nuisance, but the one shown at *G* in the illustration is of the noiseless type, hence there is no trouble from this source, which will be appreciated by those that have used the noisy kind.

As the boiler is of the upright type, and the engine so short that it occupies but little more space than a vertical engine, and since the separator is located high enough to be out of the way, the ground space occupied by the plant is small. The economy and convenience of the plant while in operation is in pleasing contrast with the wastefulness and awkward design of many small plants found in every city.

RAILWAY EMPLOYES

THE number of persons employed by the railways of the United States on June 30, 1899, as given by the report of the Interstate Commerce Commission, was 928,924, or an average of 495 employes per 100 miles of line. As compared with the number employed on June 30, 1898, there was an increase of 54,366, or 21 per 100 miles of line. From the classification of these employes it appears that there were 39,970 enginemen, 41,152 firemen, 28,232 conductors, and 69,497 other trainmen. There were 48,686 switchmen, flagmen, and watchmen. Upon the basis of special returns made to the secretary of the commission, it appears that the number of switchmen, flagmen, and watchmen included in this aggregate could fairly be assigned in the proportion of 6, 3, and 2, respectively.

Disregarding 9,334 employes not assigned to the four general divisions of employment, it is found that the services of 34,170 employes were required for general administration, 287,163 for maintenance of way and structures, 180,749 for maintenance of equipment, and 417,508 for conducting transportation.

The report contains a statement of the average daily compensation of eighteen classes of employes for eight years, beginning with 1892. A summary in the report also gives the total compensation of more than 99 per cent. of railway employes for the fiscal years 1895 to 1899. During the year ending June 30, 1899, $522,967,896 was paid in wages and salaries, an amount $77,459,635 in excess of that paid during 1895. The compensation of the employes of railways for 1899 represents 60 per cent. of the operating expenses, and 40 per cent. of the gross earnings.

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A STUDY OF SOME OCEAN WRECKS

Geo. E. Walsh

INSUFFICIENCY OF LIGHTHOUSE PROTECTION—THE PRINCIPAL DANGER SPOTS OF THE WORLD. STRANGE ACCIDENTS—MODERN METHODS OF RAISING SUNKEN SHIPS

A STUDY of ocean wrecks enables the engineer, the marine architect, and the practical navigator to draw conclusions that may, sooner or later, be of inestimable value in emergencies, and in the whole history of the evolution of the steamship there has been nothing more helpful than the practical lessons drawn from disastrous experiences on the sea. A great accident on land or an appalling wreck at sea has, time and again, stirred a nation to undertake reforms that have added greatly to the safety of the traveling public. It is not always due to lax oversight on the part of transportation companies or governments that such disasters occur, but human ingenuity and foresight have failed in advance to detect the weakness or defect in the machinery or system that was alone responsible for the accident. There will always be an element of uncertainty in traveling, and the engineer and inventor does not guarantee to eliminate this, but merely promises to minimise it as much as possible. More than this no human creature can do, and after all the promises and guarantees, accidents will happen.

The difficulty of guarding against disasters is far greater on sea than on land. Railroad travel can be made far more efficient and safe with the same expenditure of energy and money than sailing on the high seas. Here the great pathways of the steamers change and shift with each recurring storm; fogs and hurricanes drift across them and confuse navigator and captain; icebergs float down from the northern seas to menace the ships of commerce that come in their direction; derelicts wander about to trip the handsome greyhound and mortally wound her; and rocks and shoals, reefs and sandbars erect their ugly heads above the angry waters, to destroy life and property. The great waterways of the world are thus strewn with menacing dangers that no amount of science and skill can entirely obviate. The "ships that pass in the night" are more truly typical of the uncertainty of existence on the ocean than many that quote the common phrase ever imagine.

Considering the nature of the storms, rocks, reefs, fogs, and other dangers, the wonder is that more accidents at sea do not happen. It is only comparatively once in a great while that an ocean greyhound is wrecked. The unfortunate disaster to the Paris, at the Manacles, a few years ago emphasizes the fact that conditions that will be a menace to ships can prevail at times along the best regulated coast, and only through the cooperation of skilled seamen on land and ship can disaster be averted. The construction of lighthouses, buoys, beacons, and other warning signals have undoubtedly saved thousands of ships from destruction; but there is every reason to suppose that the signals of very few coasts are perfect. Great Britain and the United States lead all other nations in the effort to make navigation as safe as possible by signals and warnings, and the two governments combined have spent millions of dollars in the effort to make commerce along their coasts safe. The American coasts, including those of the Great Lakes, are guarded by some 1,500 lighthouses, and Great Britain has distributed about 1,000 along her rocky shores. Altogether, the governments of the world have erected about 10,000 lighthouses, and fully three-fourths of these have been constructed in the past twenty-five years. But even these are inadequate to the needs of commerce. There is in the possession of the Admiralty of every nation at this time an elaborate chart showing the needs and defects of nearly every stretch of coast in the world, where either new lighthouses or buoys are demanded or the old ones should be replaced by more powerful and modern-equipped signals. It is not only probable, but an almost assured fact, that the next quarter of a century will witness more wonderful changes in lighthouse building than the quarter just closed. Not only in the number of lighthouses constructed will this activity be noticeable, but in the improvement of lights and methods of signaling. Prior to 1890 gas or oil was used almost exclusively in the lighthouses for illuminating purposes, but today electricity has taken the place of these, and the power and intensity of the lights has been almost doubled;

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electric buoys have taken the place of gas or oil buoys, and almost humanly-sensitive whistling and ringing buoys now sound warnings to mariners approaching danger at the mouths of harbors; the foghorns and signals have been elaborated so that they now perform work that it was formerly impossible to accomplish. In the whole realm of lighthouse improvements science has steadily advanced and created changes that help to minimize the dangers of ocean navigation.

Nature seems to have arranged at different points along the coasts of the world all the elements necessary to make navigation difficult and dangerous, and at these particular spots wrecks are more frequent than elsewhere. Tides, winds, rocks, and reefs combine with fogs and storms to neutralize all the efforts of man to warn mariners of their danger. Important graveyards of the world's shipping are located at the Manacles, Cape Hatteras, Cape Cod, the Newfoundland Banks, and Land's End, England. At all of these points wrecks have been numerous and disastrous because they are in the track of ocean-going steamers. A terrible array of disasters could be brought against these danger points. The work of devising methods of warning ships away from them has not yet been sufficient to lessen the evil materially. The history of the Manacles is wrapped up in the history of over fifty wrecks in the past quarter of a century, culminating in the tragedy of the Mohegan and the fate of the Paris. The loss of life at this place is almost as great as that of property. Most of the ships were small sailing craft that were driven out of their course by the powerful tides and strong winds, but there has been a sufficient sprinkling of steamers to show that the very best craft afloat is not proof against the combined powers of the elements. In the Mohegan disaster alone over 100 people lost their lives. The heavy sea that runs at this point most of the time makes rescue from wrecks a doubtful matter, and more lives have been lost than saved by the life-saving station men who labor there in the interests of humanity.

The Newfoundland Banks have been the graveyard of so many important wrecks that, everything considered, it deserves to be placed first on the list of danger points. It is really the most dangerous spot on the high seas. Here the wrecks are counted by the hundreds, confined to no nationality and to no special variety of craft. The intense fogs on the Banks have been the chief cause of the accidents. Collisions in the fog have been the nightmare of passengers and captains for the past century. The danger from running into icebergs in the fogs is almost as great as that of colliding with other ships and derelicts. Owing to the numerous wrecks of the fishing fleets, the death rate on the Banks is much higher than anywhere else on the sea. Thousands of fishermen and hundreds of boats resort to that place in the spring of the year, and on an average from 75 to 100 men are drowned from these fleets every year. Many of the boats are caught in the storms and swamped, and others are run into by the ocean steamers that come shooting out of the fog and crash through a fleet of small schooners before the sailors have time to put on lifebelts. Many of these accidents are not reported by the captains of the steamers, and the records are kept only in the small fishing hamlets where missing members are mourned. Time and again efforts have been made to induce steamships to cease cutting across the Banks of Newfoundland, especially during the fishing season, when the waters are full of small boats. These accidents attract general attention only when it is the steamer and not the fishing schooners that suffers in the collision. If the steamer is struck at a right angle by the fishing schooner she is very apt to be disabled, and this has happened just enough times to make navigators more cautious than formerly in their run across the Banks. The risk alike to ocean vessels and fishing craft is sufficiently great to demand attention. Nine out of every ten collisions occur on the southern edge of the Grand Bank, where many of the steamers pass.

The other two great graveyards of the ships of commerce are at Cape Cod and Cape Hatteras. Every time a southern hurricane sweeps up the Atlantic Coast it casts scores of vessels adrift and washes many of them upon the reefs and sandbanks of Cape Hatteras. Hundreds of large and small steamers have been wrecked on this treacherous coast, and the combined efforts of lightships and lighthouses fail to warn mariners in time of the danger that threatens them at this point. The question of making these two dreaded capes comparatively safe for steamers and sailing vessels is one that has long engaged the attention of the American Government. After each heavy storm the waters in the vicinity are strewn with so many abandoned derelicts that traveling

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is made exceedingly precarious on the sea until a war vessel has been despatched to blow up the abandoned wrecks. It is estimated roughly that Cape Hatteras demands an annual tribute of $1,000,000 from the commerce of the world and several dozen lives, while Cape Cod requires nearly half as much to satisfy her angry billows. Some seasons these amounts are doubled, and again the damage may be insignificant.

These conspicuous danger spots on the charts of the ocean are reenforced by numerous smaller ones, such as Cape Horn, which might prove just as formidable if they lay more in the direct path of commerce. The mooted question today is whether anything can be done to blot out the tales of tragedy that come from these danger spots every season. They give more concern to the Lighthouse Boards and Admiralties of the world's navies than all of the other problems connected with the sea. It has been pretty conclusively demonstrated that science is helpless when caught in the grasp of the elements at these exposed points, and the only way to avoid shipwrecks there is to warn vessels away in time. The best way to do this is still a matter of uncertainty. But in the next quarter of a century some way will be found to lessen, if not to eliminate, the danger.

While the majority of the wrecks can be attributed to the storms and an untoward conjunction of the wild elements at certain dangerous points, a large number are due to strange causes that make them peculiarly interesting and sometimes puzzling to the maritime world. What strange fatality sent the steamer Oregon to the bottom off Fire Island years ago? Sailing on a quiet sea, with plenty of deep water between her and the land, and within a few miles of her final destination, she suddenly goes to the bottom from a wound in her side that neither crew nor passengers can explain. The schooner that is supposed to have delivered the blow was never identified, and if she existed at all no one apparently knows whether she is afloat or at the bottom of the sea today. The sinking of the St. Nazarre, of the French line, only a few years ago, is enough of a mystery to cause one to speculate as to the unknown dangers of the sea. Early in the evening she was suddenly found to be sinking, and half a dozen plates and bolts in her hull were found to be loosened. But what caused the trouble? A submerged wreck, probably. The steamer foundered in a short time, and her crew and passengers were barely saved in time. Captain Jagueneau, who refused to leave his sinking ship, was the only one who lost his life in the disaster.

The strangeness of these accidents at sea are made less difficult to understand by an examination of those that occur in ports and harbors, where it would seem there was no reason whatever for an accident such as occurred. A little thing has often been the cause of great marine accidents. At times it seems inexplicable that a fine ocean-going steamer that has traversed the high seas for years, buffeting heavy storms and waves successfully, should go to the bottom of some quiet harbor, to rest ignobly in the mud. Even powerful war ships have been wrecked in port, after long years of noble service in severe battles and tempestuous seas. The blowing up of a war ship in port, such as that of the Maine in Havana harbor, is exceptional, for while the reason for the deed may never be revealed, the actual cause of the disaster was due to an explosion of considerable magnitude. With her great number of warships in commission, and scattered all over the world, it is not strange that England's navy has some queer records of accidents in port. One of the saddest in history is that of the capsizing of the battleship Royal George, on August 29, 1782, when over 700 people were drowned. The ship was keeled over on one side, off Spithead, at the mouth of the Thames, for the purpose of making some slight repairs, when a land breeze suddenly swept down upon her. The stays that were used to hold the battleship from keeling over too far suddenly parted, and the magnificent vessel rolled over on her side, plunging her crew and visitors into the choppy sea. There was a short time of wild commotion, as many women and children were on board visiting the ship and their friends among the crew, and it was impossible to reach the side of the battleship in time to save many lives. There are two other remarkable instances of capsizing in or near port. One was that of the English sailing frigate Euridice, when used as a training ship. She had 300 boys on board, and was returning to England after a long cruise around Bermuda, in which she had encountered heavy weather. When off Dunnose Head, near Ventorr, a popular watering place where hundreds of people were watching the stately ship, a snow squall suddenly struck her and she capsized and sunk before help could reach her, carrying down with her nearly every man on board. It was a strange and unexplainable accident, for the squall was not

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half as severe as some she had encountered in the West Indies.

The case of H. M. S. Captain, in the Bay of Biscay, on September 7, 1870, is somewhat similar. There was one difference, however, that was probably largely responsible for the accident. The Captain was a top-heavy craft, as she was one of the first of the so-called turret ships, and the architects had not then learned the science of distributing the weight properly. A squall suddenly struck her, and she capsized without warning. Of the 490 people on board only eighteen escaped.

In more recent times accidents arising from as simple causes fill the account books of the marine underwriters with heavy salvage losses. Today when a ship is wrecked the underwriters demand a rigid examination at once, and usually photographs are immediately taken of the disabled vessel, to serve as evidence in any trial. As the underwriters are responsible for the full value of the ship and cargo, the owners sometimes show less zeal in rescuing the wreck than they would exhibit if they had to suffer the loss alone. Consequently ships have been abandoned in the past as wrecks when in reality they were not, and to prevent any such fraud the underwriters have their men on the field as soon as possible.

The methods of raising sunken ships in water that is shallow enough to permit of regular operations have changed gradually, and new schemes are being tried with success every few years. The process most in vogue in recent years is simply to close all the holes and apertures in the hull, pump out the water, and use pontoons and chains to raise her. Thus the Wells City, in New York harbor, was successfully raised from its muddy bed. She was a heavy steamer of 3,000 tons burden, and in collision with another vessel she went down in fifty feet of water. Her cargo was first removed to lighten her, and then chains were passed under her keel and around pontoons on either side. The sharp keel cut the chains in two when the steamer was raised almost to the surface, necessitating a repetition of the whole work; but she was finally raised, repaired, and turned over for active service again.

In more recent years a new method has been adopted and successfully pursued in some instances where the vessels went down in water not too deep. When a heavy vessel goes down, the lower part of the hull sinks so deep into the mud or sand that a tremendous force would be required to overcome the suction of the bed in which she lays. To overcome the friction of this mud, powerful jets of water have been poured into the bed to disintegrate the mud. In some cases, suction dredges are used to draw the mud away so that the lower part of the hull would be released from its prison.

Two years ago the powerful battleship Victorious ran aground in 25 feet of water, near the jetties of Port Said. Huge wrecking tugs tried in vain to pull her into deep water. Then one of her anchors was dropped overboard, and by attaching the chain of this to a donkey engine on board the ship was pulled along for 300 feet, until she was in 26 feet of water. But it was feared that the ship would be badly damaged if further strain were imposed upon her, and the proposition was made and accepted to try the suction dredger. The tank boats disintegrated the mud with their jets of water exerted by a powerful pressure, and the dredges sucked up the mud and dirt on the opposite side. A regular canal was thus dug around and under the heavy battleship. At the same time the tugs pulled on the ship, and in a short time she was slowly moved from her moorings. In this way she was gradually floated to deeper water, where she could manage herself. The damage to the ship was very small, while the probable danger of leaving her in her muddy bed was great. The mud was of such a character that the battleship might have sunk a little more each day until her decks would be awash with the surface of the water.

The Russian cruiser Rossia, with a displacement of over 12,000 tons, was sunk in an accident in the Neva River, near St. Petersburg, where she settled to a depth of 30 inches in the mud and sand. It was in the month of November, and the water was so cold that the divers could not work long at a time under the water, and after fruitless attempts to move the steamer from her bed it was decided to try the new method. A lighter carrying a large force pump was anchored alongside of the cruiser, and the divers carried the pipe, which was 25 inches in diameter, twenty-five feet beneath the surface of the ice. The force of the pump slowly disintegrated the frozen mud and sand, and in less than a month the heavy cruiser was floated. Had the work been performed in ordinary weather, not half the time would have been required. The ice on the river and the coldness of the water made work necessarily slow and difficult.

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MAIN STEAM PIPES

Chas. J. Mason

DESIGNS FOR CENTRAL STATIONS—PROVISIONS FOR CONTINUOUS OPERATION—METHOD OF HANGING LARGE PIPES—VALUE OF COVERING

THERE are various designs employed for the piping in large steam plants, both in regard to the method of joining the pipes and of affixing the attachments, and also in the manner of running the pipes from the boilers to the engines. The two systems now in vogue are the overhead and that where the pipes are run below the floor. Each of these systems possesses advantages not claimed by the other, and the matter of making a choice between them depends largely on the relative positions of the boilers and engines and on the symmetry of the plant—or, rather, the building itself.

One of the main objects to be kept in view in the design of a main steam pipe is that the shutting down of any one or more units will not necessitate the shutting down of the whole plant. This is accomplished in various ways. In some cases one main pipe receives steam from the boilers through smaller pipes, in which are placed stop-valves to allow steam to be shut off from any one or more boilers without interfering with any of the others; the engines have a similar pipe and valve, which admits of one or more being shut down while the others are in operation. This is all very good so far as it goes, but should anything go wrong with any part of the main pipe itself, the whole plant would have to be shut down in order to make repairs or alterations.

A plant having but one main steam pipe may be so designed, however, that not only may each individual boiler and engine be cut out of service, but if any one section of the pipe itself gives out that particular part may be cut out of service without stopping either the boilers or engines. This may be accomplished by placing the main pipe between the boilers and engines, and may be either an overhead installation or one below the level of the engines and boilers. Four stop-valves may be placed on the endless pipe, which divides it into as many sections, and each boiler and engine has then two pipes connecting with the two nearest sections of the main, and each of these individual pipes has a stop-valve also.

Now, suppose a joint blows out or anything occurs in the section of the main pipe between any two valves; the valves on the section may be closed, together with those on the boiler and engine pipes connected to the section. This will not necessitate the cutting out of service of these units, for the remaining pipe on both boiler and engine connects with another section of the main that is still in operation. In this design, all of the pipes are of such a size that these changes will not seriously affect the operation of either boilers or engines. The steam and water can be blown out through the drains (each section having a drain pipe to the sewer as well as to the regular returns to the boilers) and repairs made. After the repairs are completed, steam may be admitted through the by-pass valves, first cracking them from the seats, until the whole pipe is of the same temperature and pressure throughout; then the main valves may be slowly opened and the whole pipe is in service again.

In this way any section of the main pipe may be cut out of service and yet not interfere with the operation of any single unit in the whole plant. Expansion may be provided for, both in the main pipe and in the smaller pipes to boilers and engines, by the bends necessary to make the connections. The water of condensation (if an overhead pipe) may be collected at various points on the main into a drip line and returned to the boilers by gravity. Should the main be under the floor, the water of condensation will be conducted to a receiver that has a pump-governor attachment and pumped thence into the regular feed-line to the boiler. Provision may be made to drain any and all sections by a pipe connection into the sewer or receiving tank.

Such a design as just described is simple and no more difficult to construct and erect than any other. Having no dead ends (while the whole pipe is in service), there is little or no chance for slugs of water to do any serious damage. It is also economical of space, which is an important consideration in a design. The possibility of a complete shutdown is very remote indeed when such a pipe is installed.

Another design for the main pipe for a

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large plant, as for instance a central lighting or power station, is where the boilers are situated on either side of a central fire room adjacent to the engine room. The engines may be located with respect to the boilers in a manner similar to that described in the preceding installation, and a central passageway divides them into two groups. There are then two main steam pipes of the same size and length, running in parallel overhead. These pipes taper down toward the engine-room end. The pipes are run comparatively close together and centrally between the boilers and engines. Each boiler is equipped with two steam pipes, one pipe connecting into each main. Each boiler pipe has a stop-valve situated at the top end, close up to the main pipe. All valves in this design are fitted with by-passes.

Each engine is equipped with two steam pipes, one from each main, having stop-valves at the upper ends, the same as the boiler pipes. There is also the regular engine stop-valve (in lieu of, and sometimes spoken of, as a throttle valve) between the steam chest and the bottom of the separators. Expansion is taken care of in all the pipes by the bends. The water of condensation is collected in a line pipe running under and close to the mains, each main having its own pipe. These drip pipes, as they are termed, are connected to the mains by water pockets, which are fittings attached as a valve would be, and spaced at regular intervals along the entire length of the pipe, excepting that part where the bend is. In the boiler-room section these drip pipes return the condensation to the boilers by the force of gravity. Each pipe is equipped with a valve at every opening, and each branch pipe to the several boilers is also equipped with a stop- and a check-valve. There is also at both the fire-room and engine ends of each pipe a drain pipe that connects only with the sewer, and these are to be used when it is required to entirely empty the pipes after the steam has been shut off.

The condensation in the engine-room section of the pipe is led to traps that empty into a receiver in conjunction with a pump that delivers immediately into the feed system. These traps also have a by-pass into the sewer, to be used in case of emergency. There are two of these receivers and pumps, one on each side of the basement in which they are located. In accordance with the general plan of the whole system, the drips from both mains can be emptied into either receiver by the manipulation of the several valves. This admits of the shutting down of one pump and its receiver for repairs without in any way impairing the regular operation; each pump and receiver is of sufficient size to handle all the water that reaches it. At the base of the separator there is also a drip pipe, and the condensation from this and the live steam with which the cylinders are jacketed empties into the system. It may be added that owing to these two last sources being below the plane of the water level in the boilers, a gravity system such as is used in the boiler-room sections could not be used with any degree of success.

With this arrangement two valves are placed on each main pipe and one on a cross-pipe connecting the mains together; two of the valves on the main pipe are in the boiler room and two in the engine room, and that on the cross-pipe is situated between the dividing walls of the boiler and the engine rooms, the enclosed space being that part of the building through which the chimney rises. There is thus a main stop-valve for each pipe in both the boiler and the engine rooms. The advantage of this arrangement is twofold: First, should the pipe in the fire-room give out at any point, the valves in that section can be closed without going to the engine room to close the valves there; and so, also, in case a section of the pipe in the engine room gives out, the nearest valves can be closed for the same reason. Should the boiler-room section of a main be cut out of service for any reason whatever, both sections in the boiler room may be continued in operation by the manipulation of the five valves.

In the event of a section of each pipe having to be cut out of service, say, for example, the engine-room section of one and the boiler-room section of the other (diagonally opposite sections), the plant could still be operated by closing two valves, one on each main pipe, and opening the other two and the one on the cross-pipe, which would be equivalent to running with one main. The other sections could also be operated in a like manner.

It is plain that in this design ample provision is made for any possible emergency. It is usual, in a plant of this kind, to operate both pipes continually, only cutting any section or sections out of service long enough to do any repairs, such as overhauling the valves, packing, or making joints. Both pipes from the boilers and engines are also in service all the time, although each of them

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is made large enough to supply the required quantity of steam from the boiler to the main and from the main to the engine. The valves are usually of the gate type, with movable seats, which admits of both valves and seats being refaced without removing the body of the valve. The pipes are most frequently hung from the ironwork of the roof by iron rods fastened to collars or bands encircling the pipe and adjusted by a turnbuckle. Every alternate rod is suspended vertically and affixed to the collar, while the other collars are connected to two rods running at an angle from either side to the trestlework above. In this manner the pipe is safely and securely hung, and at the same time it is perfectly free to expand in all directions.

As we have been dealing with the design of main steam pipes in large plants, it may be somewhat foreign to the subject to introduce that of pipe covering. However, it may be briefly mentioned that owing to the great loss of heat through radiation in an uncovered pipe, it is of great importance that at least some covering be applied, even if it is of a cheap character—not that we advise anything of a cheap quality in a steam plant, but it is best to choose the least of two evils. It is estimated that an uncovered pipe will condense approximately four times as much steam in a given time as one that is covered by a cheap quality of covering.

Aside from the necessity of covering a pipe to prevent a great loss of heat, the general appearance of the piping in a plant is very much improved by a nicely laid on covering. Nothing looks better than a well-covered pipe painted white, and with brass or black bands in contrast to the colors of the surrounding objects.

DRYING ROOMS

Thomas E. McNeill

THEIR CONSTRUCTION AND OPERATION—THE COMMON STEAM-HEATING COIL—THE AIR SUPPLY—THE TEMPERATURE

THE capacity of air to absorb or float vapor at various temperatures is the basis of the drying process. Air is the medium that conveys the water from fabrics and thus dries them, and the addition of heat to the air gives the air the property of absorbing the water more rapidly than it can when cold. Drying rooms, therefore, are furnished with heating and ventilating apparatus. Many devices have been resorted to for the purpose of reducing the amount of water in articles to be dried, and among them are wringers, centrifugal dryers, etc.

The drying room should be supplied with a constant flow of fresh warm air, circulated evenly through it in all directions among the articles to be dried. The air acts like a sponge, which, if it is freed from the water it contains, will absorb more; but with air this is impracticable, so, after it has done its work in taking up all the moisture it can, it is removed and fresh air comparatively free from moisture is supplied to take its place. This is kept up as long as necessary. Very cold air contains but little watery vapor, for the low temperature solidifies or condenses it. Fabrics, therefore, are dried more rapidly in winter than in summer if the same temperature is maintained in the drying room. The more rapidly the saturated air is removed and the fresh dry air supplied, the more quickly will the drying process proceed. This is equally true whether carried on in a natural manner, as in a hot sun and a stiff breeze on a summer day, or by artificial means in a drying room, on a winter day, with a forced circulation of warm air. The former costs nothing; the latter is attended with more or less expense, according to the proper construction and management of the parts and appliances. It is important, therefore, to use only the best system for quick and complete work. It is important also that the moisture should not be removed at too high a temperature, as it is apt to make certain goods harsh in feeling and to give them a yellow tinge.

A great deal of time, ingenuity, and money have been spent on this seemingly simple process, and it is desirable, therefore, that only the best examples should be studied and used. Experience is the best teacher, and it is very desirable to know the difficulties that others have met with and how they have been overcome. The system illustrated here is recognized as the best in use. The

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drying room may be made chiefly of wood, for ordinary buildings; or it may be made of iron, to meet the requirements of the insurance companies, as accidents have occurred through the carelessness of workmen when repairing those made of wood, which have been dried to the highest point and are therefore very inflammable.

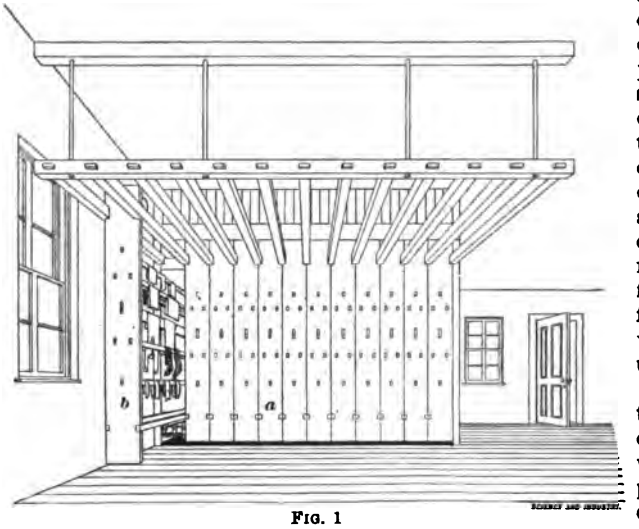

FIG. 1

Fig. 1 is a perspective view of the front of a popular type of steam drying room. It is made with three styles of horses, for plain (flat) work, as shown. These horses are 11 inches wide; special combination horses, for collars, cuffs, and shirts are 18 inches wide. They are provided with patent clips at the top for hanging the shirts, and bars with pins are used for hanging the collars and cuffs. The length of the horses varies from 10 to 15 feet, the overhead rails and other parts being made stiff and strong accordingly. The horses are made of 1½-inch clear white pine, with car-wheel rollers and galvanized-iron braces that run overhead on 4″ × 3″ rails, built up of three thicknesses of yellow pine fastened with 3-inch tinned screws and mortised into similar headers. Any number of horses may be used in one room. The illustration shows eleven in a row at *a* (closed) and one at *b* pulled out about half way. When well made, of thoroughly dried material, all the parts will work smoothly and perfectly.

Fig. 2 shows the style of steam-heating coil commonly used in a drying room. It rests on the floor. The heating pipes may run parallel with the horses or transversely, the headers being outside of the room, if necessary, and well protected. A good steam trap should be connected with the return pipe of the coil, to prevent the loss of steam if the water of condensation cannot return directly to the boiler. The proportions of the heating surface to the cubic contents of the room vary according to the class of goods and style of drying, the rapidity of the circulation of air, etc. from as high as 3 cubic feet of contents to 1 square foot of radiation down to 10 cubic feet of contents to 1 square foot of radiation. For regular work, about 7 to 1 is generally used.

The pressure and temperature of the steam, whether direct from the boiler or a weak exhaust from an engine pump, etc., must be considered. The higher the steam pressure the smaller the heating surface required.

Under certain conditions a fireproof, or nearly so, drying room is required. This must be made of and lined with metal, all parts being either thoroughly galvanized or tinned. The heads of the horses (the flat boards that form the front of the drying room) are sometimes made of wood, but thick sheet metal is preferable for a fireproof room. The tie rods are of 1¼- or 1½-inch iron pipe, and the overhead rails are of pipes or T iron. The whole must be put together firmly and substantially, with due regard to expansion and contraction.

An ample supply of air from the enclosing room or from without should be allowed to pass freely *beneath and upward through* the heating coil, and ample provision should be made for it to circulate equally among and through the articles to be dried. It should then pass through one or several openings

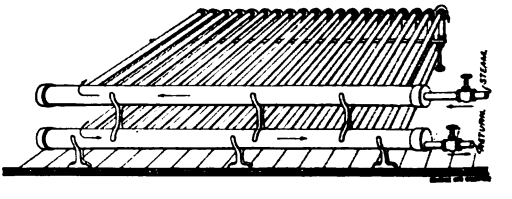

FIG. 2

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at the top of the drying room and escape through flues to the outer air. A rapid and positive circulation of the air can be secured by the aid of a power fan; in such a case the heating coil may be made more compact and be placed outside of the drying room, or an exhaust fan can be placed in the outlet flue to suck the saturated air out of the drying room.

In operating the drying room, the laundress pulls a horse out to its full length. This is easy, for the horse is furnished with wheels that run on the overhead rails, and the damp fabrics are then hung on the long horizontal bars. When these are filled the horse is pushed back again and the others pulled out one by one until they are all filled. In a few minutes the now dry clothes are removed from the first horse, which may then be refilled with other damp "pieces." In this way the drying room actually becomes a continuous-process apparatus, and the laundress loses no time waiting for the clothes to dry.

The best working temperature is from 175° F. to 200° F. for ordinary goods. Thin light goods dry as well in a somewhat lower temperature. Shirts with starch in the linen bosoms do not dry as quickly as some other goods. Woolen articles, being open and porous, can be "driven" faster than linen articles. Goods such as shirts should take not less than 30 minutes, otherwise they may turn yellow and hard. Other goods may be allowed about 10 minutes, more or less, according to their kind and the manner in which they have been "wrung out" and the dryness of the air used. In a tightly closed drying room the goods will take a long time to become even fairly dry, for the water has to condense on the walls and pass out through the pores of the wood.

A PRACTICAL LESSON

Westerner

"BOYS, I've got a nice job for you," said the superintendent of an electrical machinery repair shop one morning, when he reached the works; "here's an old one-horse 110-volt direct-current Detroit motor that we recently replaced with a larger machine; we will make a 1-kilowatt dynamo out of it; so take the motor apart and examine each part thoroughly, to see that they are free from crosses and grounds."

After these directions had been carried out the superintendent remarked: "The dynamo ought to generate 115 volts to overcome any line losses in order to give the standard voltage at the lamps; now, here is the armature—it's drum-wound, I think; the wire is heavy enough—it's No. 16. The armature is to carry, when the machine operates as a dynamo of 1 kilowatt, $\frac{1{,}000}{115}$ = 6.6 amperes. You're sure it's in good condition otherwise?"

"Well," said the foreman, "here are the field coils; we'll measure their resistance;" and this was found to be 2.6 ohms.

"Is that all?" said the superintendent; "there's 19 pounds of wire by weight; deducting 1 pound for the oil, leaves 18 pounds net. They are wound with No. 22 wire, which ought to be about 150 ohms. The small resistance is not surprising now, when I know that we never used anything but mineral oil, which in itself means death to insulation. Well, we need new wire at any rate, so we will have to rewind them, but first we will have to determine the amount of current we wish to give the fields. This should not exceed $\frac{1}{10}$ of the capacity, so we'll assume it to be $\frac{1}{2}$ ampere. This means $\frac{115}{.5}$ = 230 ohms, or 115 ohms in each coil. Now, 230 ÷ 18 = 13 ohms, nearly, or the resistance of 1 pound. No. 23 is the nearest size, so we will wind each coil with 9 pounds of No. 23 single cotton-covered magnet wire.

"I hardly think it will be necessary to do anything with the bearings, brush holders, carbon brushes, and cables—they're in good condition. When you are through winding the field coils, set the machine together again, but be sure to get the coils on the frame in the same position; connect the inside ends of the coils together, then connect the machine to the switchboard."

When this had been done the foreman reported: "All right, sir, we're ready to test her all in operative condition. Shall I start it?"

"Yes. My! but she run's swift; where's the speed indicator?"

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"Here. It indicates 3,200 revolutions per minute."

"Well, that's too fast entirely; but we won't bother about a slower speed until we learn more. But where is our current—not a sign of juice. Is the resistance cut out of the field circuit?"

"Yes."

"You are positive that all of the connections are correct?"

"Yes."

"Well, the machine will work, I'm sure."

"It only gives 5 volts on our portable voltmeter."

"Did you move the brush holders backward or forward?"

"No; that doesn't do any good."

"Is it possible that the field pole pieces have lost their residual magnetism and need strengthening? Here, put about 12 dry cells, connected 6 in series and 2 in parallel, onto the field terminals, but first disconnect one side of the armature."

"Same thing—only gives 5 volts."

"Now reverse the battery connections."

"It is still the same."

"Let's change the armature terminals."

"That is not any better."

"Well, let's try it as a motor again. We still have the current here to test by."

On this being done the superintendent remarked: "There's really nothing wrong. She runs all right there as a motor. Let's try it as a dynamo again—probably she'll work; but first we'll magnetize the fields opposite to what they were as a motor," and when this had been accomplished he said: "Now let's try it again."

This did not make matters any better, and the foreman remarked: "We have tried this thing for two days now without success. Suppose we call in an outsider and see whether he can give us some suggestion.

"All right; I'll see Mr. Contractor this morning and send him in."

In due time the gentleman mentioned made his appearance at the shop, and after matters had been explained to him he remarked: "I notice that the wiring and connections are correct and perfect; I see no reason why it should not generate. Suppose you start it up and—that's right, full speed. Well, that's funny; seems that everything I try doesn't help. Well, it's a puzzle. Suppose you try copper brushes."

"But, Mr. Contractor, we have seen carbon brushes used on dynamos and motors, both large and small; besides, we tried the dynamo as a motor and the brushes carried current. However, we will try your suggestion."

This was accordingly done, and when the foreman reported the machine ready to run again the superintendent remarked: "If she doesn't work this time I'll sell the machine for old junk," and on the machine being started he exclaimed: "Say, look at that, will you—that machine *is* a dynamo—generates 130 volts—but we can adjust that later. The next time that we rebuild a dynamo I think we can find a remedy for our trouble."

RAILWAY RECEIVERSHIPS

THE number of railways in the hands of receivers on June 30, 1899, in the United States, was 71, there being a net decrease of 23 as compared with the corresponding date of the previous year. The number of railways placed in charge of receivers during the year was 16, and the number removed from their management was 39. The operated mileage of the roads under receivers on June 30, 1899, was 9,853.13 miles, of which 7,225.62 miles were owned by them. Of the roads in the hands of receivers on the date named 10 had an operated mileage in excess of 300 miles, 10 between 100 and 300 miles, and 40 less than 100 miles. Complete returns for roads in the custody of the courts are not always available, but it appears that the capital stock represented by railways under receiverships on June 30, 1899, was about $220,210,688; funded debt $306,486,740, and current liabilities $59,180,823. These figures show a decrease of $43,926,703 in capital stock represented, as compared with the previous year, and of $16,405,951 in funded debt.

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LEAD-PIPE WORK

Sanitary Engineer

REASONS FOR THE DECLINE AND REVIVAL OF THIS CLASS OF WORK—SUGGESTIONS FOR THE IRON-PIPE PLUMBER

THE art of working lead pipe properly is supposed by many to be on the decline, for iron and brass pipes have largely superseded the use of lead pipes. Indeed, we often hear it said that first-class lead workers are "as scarce as hen's teeth," and that the plumber, instead of being a worker in lead, is nothing but an iron-pipe fitter. It is true that lead-pipe work has been on the decline for a number of years back, but it is coming up again about as fast as it went down. Two prominent causes operated together in switching public opinion from lead pipe to iron pipe; these were: economy in cost of material, and "botch" workmen who never served an apprenticeship nor received instruction, and consequently lacked the practical and theoretical knowledge that every workman must have before he is master of the art of lead working. The latter was, no doubt, the more potent cause, for hosts of plumbers were kept busy repairing leaks and other defects in the lead-pipe work of these incompetents.

It is strange but nevertheless true that a lead-pipe job installed by a first class and careful plumber who takes pride in his work will last, practically speaking, forever; numerous old buildings today bear testimony to that fact. But a lead-pipe job installed by a "botch," that leech of the plumbing trade, is a dangerous nuisance that requires repairs all the time. A "shoddy" lead-pipe job is considerably worse than a "shoddy" iron-pipe job, but a good lead-pipe job is superior in every respect to a good iron-pipe job. The chief objections to iron pipe are: (1) its short period of usefulness, which varies with the quality of the pipe, of the water, and of the zinc coating, and the degree of thoroughness with which the pipe is coated inside; (2) its liability to chokage by corrosion; and (3) the great resistances to the flow of fluid through it, due to the rough internal surface and the short sharp fittings employed in connecting the several pieces of pipe. Indeed, the objections to iron pipe are so pronounced that plumbers prefer to install brass pipe when the owner is willing to pay the increased cost.

To show that the art of lead working is not yet dead, we illustrate an exceedingly neat and masterly piece of lead-pipe work. It was made by a plumber who certainly loves his business and takes particular pride in bending lead pipes and wiping joints. The outer pipe, or frame, is composed of 2- or 3-inch waste pipe; the pipe next in size is probably 1¼-inch waste pipe; and the other short pieces, presumably, are water pipe.

All people who have tried to bend 2-inch or 3-inch waste pipe will admire the skill of the artisan who bent these pipes, for they are perfect in form; and all who have tried to wipe joints cannot fail to admire the elegance, similarity, and uniformity of these joints.

A further proof that lead-pipe plumbing is thoroughly desirable when properly done is the fact that all schools of plumbing, in which manual instruction is given, devote much time to lead work; the graduates there-

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fore naturally become not only good lead workers but also strong advocates of lead-pipe plumbing. These graduates are rapidly increasing in number, and, being educated, will soon control the plumbing trade, hence the prospects of a rapid revival of lead-pipe plumbing. The iron-pipe plumber of today may soon have to take a back seat if he does not devote his energies to mastering the art of lead-pipe plumbing. Young plumbers, take notice and govern yourselves accordingly.

THE AGE OF STEEL

W. Scott-Collins

MAN'S INVENTIVE GENIUS—IRON AND STEEL AS FACTORS OF CIVILIZATION—STATISTICS OF PRODUCTION—METALLIC FURNISHINGS AND FURNITURE—AN UP-TO-DATE OFFICE FIXTURE

"When Nature her great masterpiece design'd,
And framed her last, best work, the human mind,
Her eye intent on all the mazy plan,
She form'd of various parts the various man." —BURNS.

THAT necessity is the mother of invention is more than ever exemplified in the products of the brain and brawn of artistic and mechanical genius. When the mind works in unison with the hand, and when an inventive and resourceful spirit supremely commands the intellect, then, and only then, does the mystic words "*open sesame*" swing the portal and disclose the hidden treasure of accomplishment. It has been well said that "adversity makes the man," and, likewise, it is the grappling with the every-day problems of material things that sharpens and cultures the perception of the worker in the crafts. Whether a designer or an artisan, the same law holds, for while the skill of creative merit calls forth from the unseen, novel and striking suggestions, they must be materialized by the mechanic, and produced profitably, ere the world at large can benefit thereby. Verily, in the mechanical arts, as poetically expressed:

"INTELLECT now has assumed
An attitude truly commanding!"

so that he, with this Aladdin's lamp, who was formerly but a serf, destined to obscurity, is now the bone and sinew, and the ornament and guard of the nation.

From the days of Tubal-cain, the patriarchal ancestor of brass and iron workers, to this, the dawn of the twentieth century, no element in the world's composition has rendered greater service in advancing man's rapid development than has the unassuming and uninviting metal known as IRON. As a learned writer has stated in an historical notice of this material, "Whatever may have been the characteristics of the mythic age of gold, it is certain that man could only attain to a high degree of civilization in the age of iron; for without that metal, nations never rise out of the completest barbarism. Its possession by any people is equivalent to their advancement in all those arts and sciences which promote the happiness of the many, while leading to the enrichment of the few." For this reason, probably, it is mentioned in the earliest records of Holy Writ, and constant reference is made to weapons and implements made therefrom. There is little doubt but that iron furnaces were included in the mechanical equipment of Egypt—the cradle of the arts—as such colossal structures as the pyramids, temples, and obelisks could never have been executed without the aid of iron tools. That iron was highly valued by the ancient Greeks is evidenced by the fact that Homer, in referring to the funeral games which Achilles celebrated in honor of Patroclus, mentions that a mass of iron was given as one of the prizes.

During the Dark Ages, following the conflict waged between the barbarians of Northern Europe and the Romans, and resulting in the fall of the Roman Empire in the fifth century, the art of working iron nearly disappeared. Not until the Revival of Learning, in the thirteenth century, when "the soul of man" began to assert itself as a factor greater than "the body of man," did the art receive the attention to which it was entitled. From this time on, iron was utilized in a large degree for articles of domestic use and for constructive, decorative, and mechanical devices, such as cooking and general household utensils, window guards, hinges and locks, fireplace fixtures, armor, and weapons.

The development of the iron industry in

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Great Britain was remarkably tardy, which may be accounted for by the centuries of warfare between the Islanders and their Continental aggressors—impelled by the love of conquest—and the decades of medieval broils between the feudal nobles for supremacy. During these ages of unrest—eras of contention between the moral and physical forces which constitute the molding process for empire and republic alike—little attention was given to the manufacture of iron for other purposes than weapons and trappings of offense and defense. Although iron was mined and smelted in England during the time of the Romans, for generations the mines were left wholly unworked. As late as the reign of Edward III, in the fourteenth century, the iron pots and pans of the royal kitchen were listed among the jewels of his majesty! And these were doubtless from metal procured from Spain or Germany. In the middle of the eighteenth century four-fifths of the iron worked in Great Britain was imported from Sweden. As seven loads of wood were required to produce a ton of bar iron under the old smelting processes, it can be seen that the entire country would soon have been denuded if much of it had been produced.

It was not until coal was successfully employed for smelting purposes that the production of iron became extensive and remunerative. In 1620 the British metal commenced its forward march; in 1760 large blowing cylinders were erected by the celebrated Smeaton, and this added improvement gave a phenomenal impetus to the trade. In 1806 the product was 250,000 tons; in 1876, nearly 6,000,000 tons, and in 1898 nearly 9,000,000 tons. In the United States nearly 12,000,000 tons of pig iron (or one-third of the world's product) was manufactured in 1898, of which 9,000,000 were converted into steel. To give one a conception of the magnitude of the iron and steel interests of the world, it might be well to state that in 1898 the globe yielded, and her dwellers prepared, no less than 36,507,487 tons of pig iron, of which 24,060,500 were converted into steel—the combined products of Great Britain and the United States thus being about 60 per cent. of the entire output.

While enormous quantities of steel are used for military ordnance and arms; railway bridges, and structures, track rails—"*those glistening lines that bind the earth*"—locomotive, car, and mechanical equipment; motors and mechanism in work shops and industrial plants; and for general architectural and engineering achievements, we find that it is rapidly pushing its way into domestic and business circles. Door mats are made of steel ribbons, wardrobes are equipped with steel hangers, pictures are suspended by steel wire, pianos give forth their melody from steel chords, bedsteads are constructed of steel, downy couches are supported by steel trellises and springs, bathtubs are made of it, the kitchen and laundry outfits are mostly composed of steel, and the entire household assumes a peaceful aspect when mother-in-law steals an afternoon nap in a steel-rigged rocker.

In business life its presence is even more pronounced. In the new offices and stores the skeletons of the structures are composed of this metal; we are quickly transported in elevator cars made of it and suspended and hauled by steel cables. The stairways are more or less indebted to steel for carrying members and balustrades; doors, shutters, and ceilings are steel-clad, and now the rich oak and mahogany office fixtures are informed that "their days of usefulness have ended" and the old order of things must make way for the new.

A recent visit to the works of the Art Metal Construction Company, of Jamestown, N. Y., vividly portrayed the rapid advancement being made in the design and construction of metallic fixtures. The extent and variety of the products presented an object lesson of the complex character of our present-day commercial interests. Amid an army of four hundred mechanics, "many-aproned kinds," were ranges of bank counters and grilles, filing cabinets and tiers of roller shelves, roll-top and flat-top desks, book trucks, a forest of library book stacks, piles of letter and document file cases, newspaper racks, buffets and bureaus, tables, stools and chairs, wardrobes, book cases, and mantels. In other words, a complete steel "cabinet" shop. These products are essentially a modern idea, and are certainly the embodiment of the most approved methods of construction on scientific principles. That classic architectural treatment can command this new constructive material to obey her mandates, shows how eternal is artistic truth. It maintains the maxim that utility does not sacrifice her virtue by being chaste and beautiful.

These articles of furniture are principally made of sheet steel, which possesses many merits; it does not shrink and swell as wood does, it is lighter in weight, does not absorb

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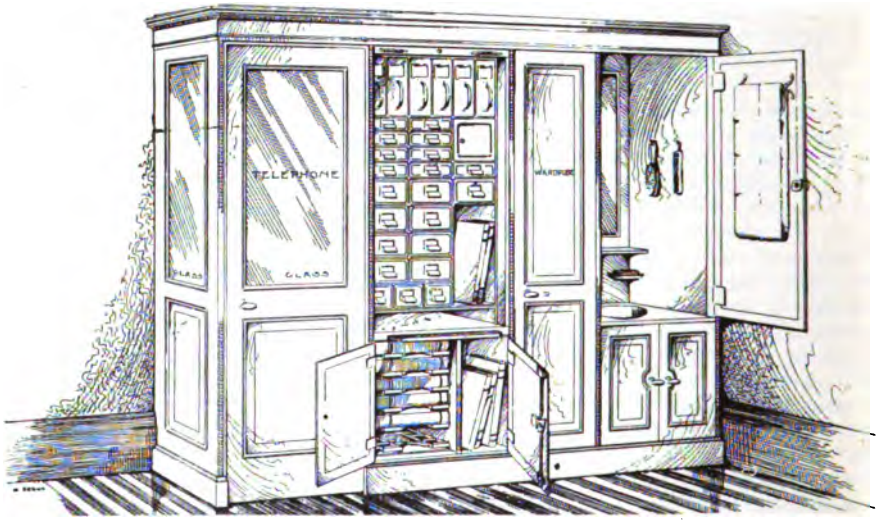
odors, and owing to its thickness is a great economizer of space. The sheets are made perfectly smooth, being pickled and cold-rolled, and are pressed, molded, and bent as desired. Particular attention is given to have all the exposed edges neatly rounded. Shelving and work of this kind is always finished with a roll-edge. The surface of the metal is rendered impervious to moisture and rust by being covered with heavy coatings of enamel paint, which is finally baked in ovens up to a temperature of 400° Fahrenheit. A full range of colors have been prepared for this class of work, so that it can be made to harmonize with any specific color scheme. Grilles and trimmings, when of steel, are plated and burnished in any of the approved finishes.



Brass and bronze moldings, ornaments, and trimmings are also used in conjunction with the enameled work, and present a most pleasing effect. The accurate and thorough workmanship displayed in the execution of the details is a marvel to one accustomed to see the general line of steelwork. The skill of the furniture steelworkers is on a par with that of the machine shop, and they occupy a field far removed from either the blacksmith or the tinker.

For interior architectural work, combinations are made of steel plate finished in appropriate colors, brass, bronze, cut and art glass, mirrors, marble, leather, and other suitable materials. The richness derived from this *ensemble* cannot be readily understood from a description; a visit to any of the modern banks, libraries, court houses, or office buildings, however, will reveal the attractive appearance and desirability of this new adaptation.

In the larger cities, where office buildings are located around the business heart of the community, floor space is held at a ransom, and any contrivance to economize the area is held in much favor by landlord and tenant alike. In the accompanying figure is shown a combination of four separate and distinct features that are requisite in every well furnished office. These consist of a telephone booth, a filing case and cabinet, a wardrobe, and a lavatory and toilet cabinet. It will be seen that valuable space is saved by such a grouping, and when one considers the thin metallic casings, the saving is more apparent. The returns for commercial enterprise are greater—

"And man, convinced by THRIFT alone,
This great important truth shall own:
That thin partitions may divide
The space where compact comfort doth reside!"

In conjunction with the economy of space is that pertaining to the methodical disposition of correspondence, documents, records, and accounts. In the filing case and cabinet are arranged 6 document files, 9 blank drawers, a safety cash compartment, 8 letter files, 1 lock drawer, 3 card index drawers, a bookstall, an atlas and folio compartment, a sliding shelf, and 6 roller shelves for large ledgers. The entire front is enclosed and protected with a rolling steel curtain depended from above—a fit covering for a veritable MULTUM IN PARVO.

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USEFUL IDEAS

TESTING THE ACTUAL CANDLEPOWER OF ARC LAMPS

Thos. C. Harris

It is sometimes desirable, for the purpose of comparison, to find the actual candlepower of a certain lamp. In such cases the test may be made with considerable accuracy by the use of a simple apparatus. On several occasions the writer was required to test the actual candlepower of a number of arc lamps, as used on the streets, and made use of a simple home-made apparatus, as shown in the diagram of Fig. 1. It is based on the well known Rumford method, which is a comparison of shadows. Since the power of a given source of light diminishes inversely as the square of the distance, it is easy to figure the candlepower when we find the point where the lamp tested exactly balances a "standard candle." If we use 1 foot as a unit of measurement, it will be only necessary to measure the distance from the shadow rod to the lamp with an ordinary tape line, and to multiply that distance by itself to give the actual candlepower.

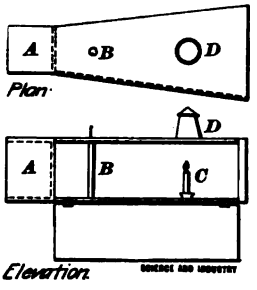

Fig. 1

By referring to the diagram it will be seen that the apparatus consists of a box about two and a half feet long and open at both ends. For convenience, it may be made somewhat flaring at the front end, and a part of one of its vertical sides should be on hinges, to allow it to be opened for adjustment of the "standard candle." At *A* is a frame carrying a ground glass or a thin plate of pure white porcelain. This forms a screen on which the shadow of the vertical rod *B* is allowed to fall. At precisely one foot in front of the center of this rod is placed a socket carrying the candle. The socket should be adjustable, in order that the distance may be precisely fixed. The shadow rod *B* is about ¼ inch in diameter and carries in the center of its upper end a long tack or wire nail, to hook the end of the tape measure on. Above the candle is the chimney and cowl *D*, and around the socket are a number of half-inch holes, to admit air. All the interior is painted a dead black with a mixture of lampblack and spirits of turpentine.

The box has two parallel cleats on its bottom, which allow it to slide to and fro along the top surface of a long trestle bench when testing an arc lamp out of doors. The manipulation is easy and simple. One end of the bench is pointed at the arc lamp, as shown in Fig. 2, which has been previously lowered to the same level as the candle, and turned just enough to one side so as to cast a shadow of the rod on the screen, parallel to and nearly touching the shadow of the rod as cast by the candle.

The two shadows then appear to the observer looking into the rear end of the box as two parallel stripes. By sliding the box along the bench, to or from the lamp, a point will soon be reached when the intensity of the two shadows will be just equal.

This determination may be reached with a considerable degree of accuracy by a person of good eyesight who is not color blind. Then with the ring on the end of the tape line hooked over the center of the rod, the distance is measured to the carbons of the lamp where the arc appears. If this distance happens to be, say, 30 feet, the power of the lamp is $30 \times 30 = 900$ candles.

There are two practical faults, or hindrances, in such a test, but both may be

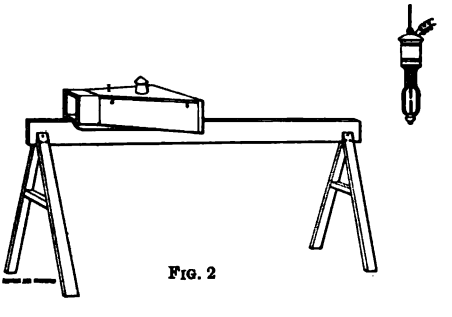

Fig. 2

overcome. First, the two shadows will have different tints of color; the one from the candle will be yellowish, while the shadow from the arc lamp will be bluish.

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To overcome this color interference, the operator should wear green spectacles, when no color will be seen—only the monochrome density of the two shadows. The other fault comes from the varying power of the electric arc in the lamp. As the carbons are consumed, the arc grows longer and longer, gradually becoming of a bluish tint and increasing in illuminating power until a point is reached when the resistance of the arc causes a portion of the current to shunt through a regulating coil in the lamp. The shunt cuts off the current through the carbons, allowing them to come into contact again, when the arc is reformed and the mechanism of the lamp lifts the upper carbon again to the distance determined on. This evolution, as described, produces a "wink" in the light and the reformed arc is not so bright as it was just before breaking, for the reason that it is shorter.

The candlepower, as noted by the observer, in the apparatus, will be seen to grow steadily as the arc grows longer, and the box must be slid away from the lamp more and more to keep the shadows of equal density until the lamp "winks" again. The power of the light will therefore appear in waves of intensity similar to a record made by an automatic tide gauge, and never constant for any considerable length of time. I refer to the ordinary open arc lamps, as used on the streets.

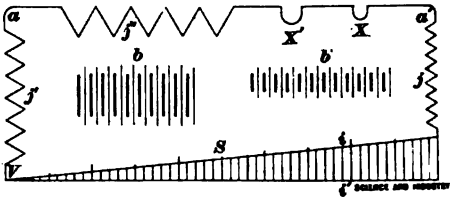
The observer can thus ascertain the power of a lamp at its different degrees of intensity, and so obtain a mean or average candlepower.

[This method is simple and convenient, but the arrangement as shown gives the intensity of illumination in the horizontal direction only, and this is hardly a fair test for an arc lamp. The lamp that gives the most light in a horizontal direction is not the best lamp for street lighting.—Ed.]

DRAWING GUIDE

D. R. P.

The instrument here described will be found very useful to every one that is called on to make diagrams of electrical machinery. It is made from a piece of transparent celluloid 2 in. × 5 in.; two corners *a* and *a'* may be rounded off to represent a corner of a circuit; the notches *X* and *X'* are for the purpose of making a line crossing another but not connected to it; *b* shows large, and *b'* small, alternate broad and narrow slots cut in the celluloid, through which the pencil can mark the lines representing batteries as they are shown by a drawing. The rule *S* is handy for making fine measurements. The division lines *i i'* must be very small, and in using this rule it should be

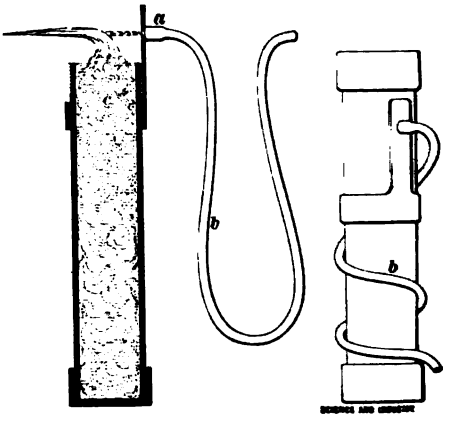


remembered that line *V i* rises .1 inch for every inch it is drawn to the right. Thus, if a line .39 inch in length is desired, measure 3.9 inches from corner *V*, and the length of the line *i i'* at that point will be .39 inch. The notches shown on the ends and side of the guide at *j*, *j'*, *j''* are for the purpose of quickly making the zigzag lines to represent resistance coils, dynamo, motor field, etc. The device is one that will save a great deal of time for those that have much work of this kind to do.

A HANDY BLOWPIPE LAMP

Will Owen, Dannevirke, New Zealand

I take pleasure in submitting to the readers of Science and Industry a simple and easily made blowpipe, which is shown in the accompanying illustration. It is made from a piece of tube about 6 inches long, and has a threaded cap on top. A small piece of sheet iron or brass is attached and held in place by a band that allows it to



slide up and down the pipe, and a pinhole pipe is fastened at *a*, to which an india rubber tube *b* with a mouthpiece is attached. When it is desired to use the blowpipe, the cap is unscrewed, enough cotton wick *c* is

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pulled out to suit the requirements of the flame desired, the slide is pulled up and the wick lighted. Then by blowing in the tube, a nice clean flame that can be regulated to suit the needs of any case is produced. Any one needing a blowpipe will find this one very useful. It is easily made, and requires the use of only one hand to manage it.

EDITORIAL COMMENT

ADVERTISING RETURNS

As an instance of direct returns from advertising, The Burt Mfg. Co., of Akron, Ohio, report that they are crowded with orders as the result of an illustrated notice of their Burt exhaust head, which they have only recently commenced to advertise, and which appeared in the September number of this magazine. "Any article of merit," said Mr. Warden, manager of the company, "can be pushed successfully through judicious advertising in the trade journals, as we have demonstrated to our own satisfaction at least."

A NEW CATALOGUE

J. Elliott Shaw & Company, the electrical supply people, of 632 Arch Street, Philadelphia, have just issued a brand new catalogue of their assortment of electrical household supplies and novelties. This is the ninth catalogue issued by this enterprising house. It was compiled and printed by a well known business writer of Philadelphia and is decidedly interesting from cover to cover. It contains more than 220 pages. It is just the sort of catalogue in which any one, no matter how slightly they may be acquainted with electricity and things electrical, will be deeply interested. Any one desiring a copy can have it by writing Messrs. Shaw & Co., 632 Arch Street, Philadelphia, and enclosing two two-cent stamps.

BOOK NOTICE

A Textbook of Mechanical Drawing and Elementary Machine Design. By John S. Reid and David Reid. Octavo, 389 pages, 301 figures. Price, $3.00. John Wiley & Sons, New York.

The authors are instructors in mechanical drawing and designing at Sibley College, Cornell University, and in the preface they state that the work was prepared as a course for sophomore students in that institution. There is an introductory chapter giving general instructions for the selection, use, and care of the instruments required by the mechanical draftsman, an explanation of the methods of representing machine details by mechanical drawings and of the most common conventional signs, a very brief outline of the strength and properties of the materials used in machine construction, and a number of tables and statements of useful facts. Each of these subdivisions is very brief, and the tables and statements of facts will be found useful principally in connection with the problems in the later parts of the book.

The main part of the book is devoted to instruction in the methods of making working drawings of machine details. Empirical rules and formulas for the design of such details as have been reduced to more or less generally accepted standards are freely used, and, in a few cases, simple applications of the principles involved in rational designing have been introduced.

The book is illustrated with a fine set of examples of the construction of machine details, many of the cuts being made from actual working drawings of some of the best examples of modern American design. In accordance with the plan of the course, the student is to make working drawings partly of details designed from the rules and formulas and partly copies to scale of the details whose dimensions are given. By following this outline, excellent practice in machine drawing and familiarity with good examples in design will be obtained; the knowledge of real machine design that will be acquired will, however, be small. As a course of instruction in the application of mechanical drawing to the representation of machine details, the work before us is one of the best we have ever seen, but it seems a little out of place to speak of it as even an *elementary* course in design. In our opinion, there is need of a more careful distinction between the terms mechanical drawing and machine design. If such distinction were more closely observed, much of the misunderstanding concerning the purpose and scope of the courses of instruction in our schools and colleges would be obviated, and there would be less disappointment with the results on the part of the student and his first employer.

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ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*
2. *Only questions of general interest to our readers will be answered.*
3. *No questions will be answered by mail.*
4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*
5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*
6. *Reference to inquiries previously answered should give date of issue and number of question.*
7. *Questions cannot be answered in the issue of the month immediately following their receipt.*
8. *Any book not out of print and for sale by regular dealers may be ordered through the magazine.*
9. *We will not undertake to calculate windings of dynamos and motors, as this involves considerable work and is seldom justified.*

MECHANICAL

(467) (*a*) What horsepower can be developed from the water flowing over a flat-crested weir under the following conditions: Head, or depth on crest, 2 feet; length of crest, 24 feet; total fall, 12 feet. (*b*) What is the discharge through a head race or flume 6 feet wide and 4 feet deep, with a head of 12 feet, the velocity not being known? (*c*) What horsepower can be developed from the water flowing through such a flume? W. L. L., Ottawa, Can.

ANS.—(*a*) The quantity of water flowing over the weir depends considerably on its width as well as on the length and head; it also depends on the velocity with which the water approaches the weir. A rough approximate estimate indicates that the flow is nearly 200 cubic feet per second. With this flow the theoretical power is about 270 horsepower. If we assume that a waterwheel delivering 60 per cent. of the theoretical power is used, the available power becomes 162 horsepower. (*b*) It is impossible without knowing the slope or rate of fall to estimate the flow through such a flume as you describe. The velocity of flow in feet per second v may be estimated by means of the formula $v = \sqrt{\frac{100{,}000\, r^2 s}{6.6\, r + 0.46}}$, in which r is the quotient obtained by dividing the area of the cross-section of the flume by the length of that part of the perimeter of the section in contact with the water, and s is the rate of fall of the flume, equals the difference in level between any two sections, divided by the distance between them measured along the flume. Having the velocity v, the discharge in cubic feet per second is found by multiplying by the area in square feet of a section of the flume. (*c*) The theoretical horsepower can be calculated from the formula H. P. $= .1132\, Q\, H$, in which Q is the discharge in cubic feet per second and H is the fall in feet.

(468) (*a*) What is the constant of an engine with the following dimensions: Cylinder, 26″ diameter and 60″ stroke; diameter of piston rod, 3½″; number of revolutions per minute, 67; boiler pressure, 100 pounds. (*b*) How is the constant calculated? H. H. W., May's Landing, N. J.

ANS.—(*a*) 10.66. (*b*) An engine constant is the indicated horsepower for 1 pound mean effective pressure. It is calculated from the formula I. H. P. $= \frac{PLAN}{33{,}000}$ by substituting 1 for the mean effective pressure P, and for the length of the stroke L, the area of the piston A, and the number of strokes N the values corresponding to the dimensions and speed of the engine. For your engine the length of stroke is $L = 5$ feet; the area of the piston is $26^2 \times .7854 = 530.93$ square inches, and of the rod $(3\frac{1}{2})^2 \times .7854 = 11.42$ square inches; the mean area of the two sides of the piston is, therefore, $A = \frac{530.93 \times 2 - 11.42}{2} = 525.22$ square inches; and the number of strokes per minute is $N = 2 \times 67 = 134$. Substituting in the formula, the value of the constant is

$$\frac{1 \times 5 \times 525.22 \times 134}{33{,}000} = 10.66.$$

By multiplying the mean effective pressure of the engine by this constant the indicated horsepower will be obtained.

* * *

(469) Please explain the action of the revolving sprinkler used to water lawns. VIRGINIA.

ANS.—The principle of this action is of the jet propulsion. Water escaping at pressure from a hole in a vessel tends to move the vessel in a direction opposite to that of the escaping jet. The sprinkler has three arms set radially, and the ends of these arms are bent horizontally at a slight angle with the main body. The arms are hollow and are secured into a kind of sleeve that rotates on an upright stem forming the body of the sprinkler, which is also hollow and communicates with the water hose connection. On the end of each arm is a small ball with half a dozen holes in it. When water is turned on it flows up the main body of the sprinkler and thence into the arms and escapes out of the holes in the ends, the reaction of the escaping water causing the combination of arms and sleeve to rotate around the sprinkler body. In the upper side of each arm is a small hole through which the water comes in a vertical jet.

* * *

(470) Please let me know how many cubic inches of gas will be required in a balloon to lift a weight of 1 lb. F. B., St. Louis, Mo.

ANS.—The volume of gas required to lift a weight of 1 lb. depends on the specific gravity of the gas as compared with air. If the specific gravity of the gas is known, the weight that will be lifted by a cubic foot is found by multiplying the weight of a cubic foot of air by the specific gravity of the gas and subtracting the product from the weight of the air. For example, the weight of a cubic foot of air under ordinary conditions may be taken at .075 lb., and the specific gravity of coal gas at .5; the weight that would be lifted by a cubic foot of the gas would then be $.075 - .075 \times .5 = .0375$ lb. To lift 1 lb., the volume of gas requ. d would be 1 + .0375 = 26⅔ cu. ft. = 46,080 cu. in.

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(471) (*a*) What is acetylene gas? (*b*) How is this gas generated? (*c*) How can this gas set fire to a wooden building from the pipes that run through plastered partitions? P. V. L., Worcester, Mass.

ANS.—(*a*) Acetylene gas is a compound of carbon and hydrogen. Its chemical symbol is C_2H_2, and its composition is 12 parts of carbon to 1 of hydrogen, by weight, or 92.3% carbon and 7.7% hydrogen. Its density compared with that of the air is .91, and its weight at 32° F. is .073 lb. per cu. ft. It is poisonous to breathe in about the same degree as ordinary illuminating gas. (*b*) Acetylene gas is manufactured by an indirect process. The first step in the process is to form a compound of carbon with calcium. This is done by subjecting a mixture of coke and lime to the intense heat of an electric furnace. The product, which is called carbide of calcium, is a gray material, opaque, somewhat crystalline, and decomposes water like ordinary quicklime. The second step in the process of manufacturing acetylene gas is to bring the carbide in contact with water. Both materials decompose. The calcium takes up oxygen from the water, forming oxide of calcium, which is common quicklime. The carbon combines with the hydrogen of the water and forms the desired compound, acetylene. Considerable heat is given off during the operation. (*c*) It is generally understood that acetylene gas leaking into a building from gas pipes cannot set fire to the woodwork unless the gas is ignited, when it will explode with greater violence than ordinary illuminating gas. As acetylene possesses a wider range of explosiveness with air than any other gas, there is more danger to the building from leaking acetylene-gas pipes than from leaking coal-gas pipes. It has been observed that all mixtures from 3% to 82% of gas with air will explode, and no other gas possesses so wide a range. The only way by which acetylene gas can be expected to set fire to a building is from ignition or explosion.

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(472) (*a*) Do you know of any solution that can be applied to the nickeled parts of a bicycle that has become somewhat rusted, same to give a finish similar to nickelplating and to be applied with a brush? Is there an aluminum fluid having such properties? (*b*) What is the method of truing a bicycle wheel? E. J. S., Brooklyn, N. Y.

ANS.—(*a*) We do not know of any plating fluid that can be applied with a brush that will give a permanent finish similar to nickelplating. Aluminum metallic paint such as is used on letter boxes would give a dull finish but it would not be very durable. We think your best plan would be to have the parts replated. (*b*) Wheels are trued by mounting them between centers on a stand made especially for the purpose and revolving past a fixed point so that the irregular parts may be noted. The rim is then pulled into its proper position by tightening or loosening up the spokes. The truing of a bicycle wheel requires considerable skill and experience, and we would advise you to take it to a good repair man. Inexperienced hands frequently get a wheel into worse condition than it was before they started to work on it.

***

(473) (*a*) What is the economical point of cut-off in a single-cylinder engine with a steam pressure of 80 pounds, in a compound engine with a pressure of 120 pounds, and in a triple-expansion engine with a pressure of 160 pounds, all condensing? (*b*) Please recommend a good book on the locomotive—one containing working drawings of the parts.

J. B., Central Falls, R. I.

ANS.—(*a*) For the single-cylinder engine, about ¼ stroke. For the compound and triple-expansion engines, the point of cut-off *b* be used in the high-pressure cylinder depends on the relative sizes of the cylinders. With the cylinder ratios most often used, cut-off at ¼ stroke in the high-pressure cylinder would probably give the most satisfactory results. (*b*) "Modern Locomotives," price $7.00; for sale by The Technical Supply Co., Scranton, Pa.

***

(474) (*a*) How shall I proceed to warm up and start a large cross-compound Greene engine with direct-connected jet condenser? Injection water is to be lifted. (*b*) Is 4,804.5 the 1.6th power of 200? (*c*) Is 8.82584 the .4th power of 200? (*d*) Is 221,806,100,000 the 5.8th power of 200?

J. S., Central Falls, R. I.

ANS.—(*a*) Without knowing the exact arrangement of the plant, we cannot give a satisfactory answer. (*b*) Yes. (*c*) No. The .4th power of 200 is 8.82554. (*d*) No. The 5.8th power of 200 is 22,180,600,000,000. We have used tables giving logarithms to 6 places.

***

(475) Please give your opinion on the following: When is the stress on the bolts that fasten a cylinder head to the cylinder greater: when the engine is standing without steam in the cylinder or when the engine is working under full pressure?

F. W. W., Laurel, Miss.

ANS.—This is an old question for which no satisfactory answer has yet been given. A satisfactory explanation of the reasons for our opinion on the subject would require too much space for these columns, and we do not care to state our opinion without an outline of our reasons for it.

***

(476) (*a*) What is meant by "turning a hammer?" (*b*) How many kinds of "fits" are used by lathe hands and mechanics, and what are their names?

W. H. B., Villisca, Iowa.

ANS.—(*a*) We have never heard this term before. Perhaps some one of our readers can enlighten you. (*b*) There are four kinds of fits, in general. These are known by the names of driving fit, shrinking fit, sliding fit, and running fit. To these may be added the term "misfit," which is self-explanatory.

***

(477) Would it be safe to pipe a 20-horsepower engine to a 3 ft. × 7 ft. vertical boiler? A. C. D.

ANS.—It will be safe enough to pipe the engine to the boiler. We think you will find the boiler rather small, however, and will not be able to keep up steam without forcing the fire considerably.

ELECTRICAL

(478) (*a*) I wish to construct a small Wimshurst machine having sectors and using two 24" glass plates. Is there a certain ratio that the length of a sector must bear to the radius of the plate? (*b*) Is there a ratio between the width of a sector and the distance between adjacent sectors? (*c*) Should the sectors be the same width from end to end, or should the distance between adjacent sectors be the same at both ends? (*d*) About what length of spark should the above machine be capable of furnishing?

A. D., Philadelphia, Pa.

ANS.—(*a*) The sectors used on Wimshurst machines vary considerably, and there is no fixed rule that we know of that determines their length. In fact, some forms of the machine have no sectors at all. Generally, however, the length of the sector is in the neighborhood of one-half the radius, though in some machines they are shorter than this. (*b*) The width of the space between the sectors depends largely on the number of sectors used. The space is, however, seldom less than the average width of the sector,

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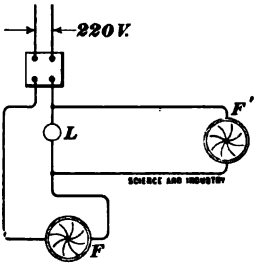
and is in most cases more. (*c*) The sectors are usually made tapered, so that the distance between them is about the same from end to end. (*d*) This depends very largely on the condition of the weather and also on the care exercised in building the machine. If everything is in favorable condition, a machine of this size should be capable of giving sparks from 5 in. to 6 in. in length. If the weather is damp or if the insulation of the machine is poor, you may not be able to get a spark of more than half this length.

***

(479) The accompanying sketch shows two 110-volt fans in series on a 220-volt circuit. *F* and *F'* are the fans and *L* is a 110-volt lamp receptacle. Now with *F'* cut out of circuit, and a lamp screwed into the receptacle, *F* runs up to speed and *L* burns up to candlepower. Now, if *F'* is cut in circuit, *F* slows down a little and *F'* turns very slowly. If *L* is unscrewed, both fans run up to speed. Am I right in saying that *L* and *F'* are in series with *F*, but in multiple with each other? If so, then *F* acts as a rheostat and cuts the voltage from 220 to 110, and *L* and *F'* being in multiple, should both get the same voltage. They evidently do not get the same voltage. Please show me where I am wrong, and if there is a principle underlying this fact, please give it. N. R. B., Atlantic City, N. J.



ANS.—It is quite correct to say that *L* and *F'* are in parallel with each other and the two in series with *F*. Suppose that lamp *L* is screwed out and that *F* and *F'* are cut in. The two fans will then be in series and will run at the same speed if they are alike. We will then have a certain current flowing through *F* and *F'*. Now, if *L* is cut in, *F'* and *L* are in parallel with each other, so that only a portion of the former current flows through *F'*. The result is that its torque or twisting effort is decreased greatly and it therefore runs slowly. *F* gets more than its share of the voltage, since the counter E. M. F. of *F'* becomes smaller owing to the decreased speed. Of course, the voltage across *F'* and *L* is the same, but it is not the same as that across *F*, and the fact that the voltage across *F'* is low is indicated by the lamp burning dimly. You state that *F* slows down a little, but it would seem as though it should speed up slightly on account of the increased voltage across its terminals.

***

(480) (*a*) I have a 230-volt, 1 H. P. motor that requires a current of 4 amperes. I would like to connect it to a 500-volt circuit without having the windings changed. I propose to do this by placing a number of lamps between the line and the motor, so as to cut down the voltage. If you think this will work all right, let me know the proper volt lamps to use and how many. (*b*) Would it be more expensive to operate the motor in this way than to use a 1 H. P. 500-volt motor if I connect the wattmeter across the motor and not across the line?

J. S. G., Carlisle, Pa.

ANS.—(*a*) This arrangement will work fairly well if the motor runs under a steady load. You must bear in mind that if the current varies, the drop through the resistance will vary, and hence the voltage applied to the motor will change, thus giving rise to very poor speed regulation. If the armature took very little current at any time, the voltage might rise high enough to give an unsafe speed or perhaps burn out the field. If, however, the current remains approximately at 4 amperes, the motor will operate all right. You can use fifteen 32 c. p. 110-volt lamps connected three in series and five in parallel. This will work the lamps at a low temperature and make their life long. (*b*) The operating expenses would be the same in either case, as you are not measuring the power wasted in the lamps. If this were taken into account, the 230-volt motor would be much more expensive, as over half the power supplied from the line is wasted. The 500-volt motor would no doubt be much more satisfactory as regards speed regulation and general operation.

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(481) (*a*) In the accompanying sketch, Fig. 1, bells *A*, *B*, and *C* are rung from button *A* when

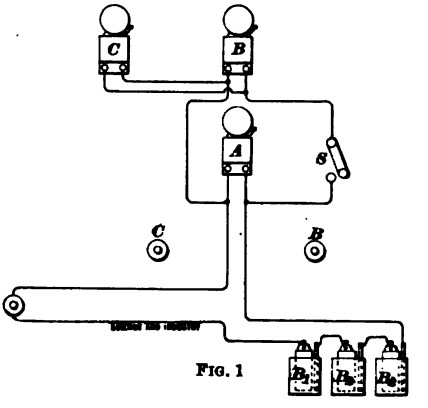

FIG. 1

switch *S* is closed. Give a diagram showing how button *B* can be connected to ring bell *B* alone and button *C* to ring bell *C* alone, when switch *S* is open and without putting in any more leads to cells B_1, B_2, and B_3. (*b*) Kindly give directions for making an accumulator to be charged from ten cells of crowfoot battery. B. R. W., Washington, D. C.

ANS.—(*a*) Fig. 2 shows a scheme of connections that may serve your purpose. With this arrange-

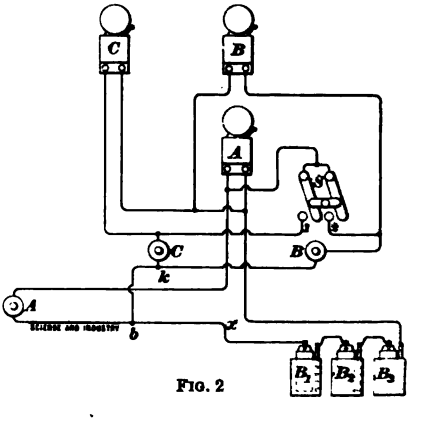

FIG. 2

ment, it is necessary to use a switch *S* having two contact points *1*, *2*. Also a wire *Ckb* must be run from *C* to connect with the wire running from *A* to the battery. It can be tapped in anywhere between *A* and *x*, but you must be sure to get it on the battery

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side of the push. The diagram will explain itself. When *S* is open and *A* is pushed, bell *A* rings. When *B* is pushed, *B* rings, and when *C* is pushed, *C* rings. When *S* is closed and *A* pushed, all three bells ring. (*b*) The ordinary type of storage cell is suitable for this purpose. See article entitled "How to Make a Storage Battery," in the June, 1900, number of this magazine. Use about four cells.

***

(482) I have two private telephone lines coming into my house, but I have only one telephone instrument. How can I, by the use of an extra bell only, arrange the bell and the telephone so that either line can ring me up, and so that I can switch the telephone on either line when I answer? I do not wish to purchase an extra telephone instrument or box. SUBSCRIBER.

ANS.—You have not stated whether your lines are complete metallic or earth return, so it will be necessary to show you how to do it for both systems. You will need one polarized, or extension, bell, as it is commonly called. A battery vibrating bell will not answer the purpose, if you have the ordinary magneto-generator and bell in your telephone instrument. In Fig. 1, *T* represents your regular telephone set or box, *E* an extension bell, *G* the ground, and *H* a mercury-cup reversing switch.

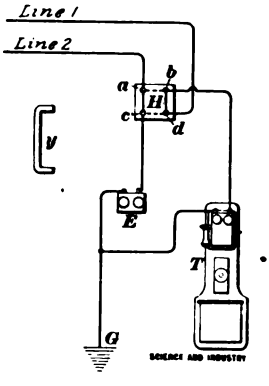

FIG. 1

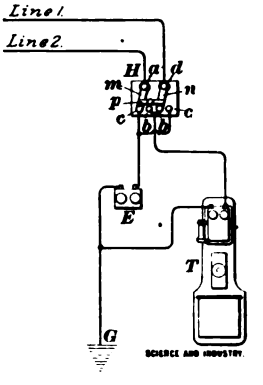

FIG. 2

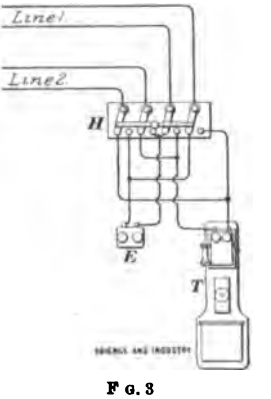

FIG. 3

This reversing switch can be made out of a block of hard wood 4 in. square by at least 1¼ in. thick. Bore near the corners (not too near, however) four ¼" holes, 1¼ in. deep, and so that hole *a* will be equally distant from holes *b* and *c*, and hole *d* exactly the same distance from *b* and *c* that *a* is from *b* and *c*. Be careful not to let the point of the bit make the slightest hole through the bottom of the wooden block, otherwise the mercury, with which the holes are to be nearly filled, will leak out. The wires running to the holes should have their ends scraped, bent into a small flat spiral, and fastened by a short tack in the bottom of the holes. The tack must not be so long as to pierce the bottom. Bend two pieces of bare copper wire, not smaller than No. 12 B. & S., into the shape shown at *y*, so they will reach from one hole to another, and the ends nearly reach the bottoms of the holes. Fill the holes about two-thirds full of mercury. Then, when the two copper wires connect *a* with *c* and *b* with *d*, as shown by the full lines on the switch *H*, you will have the telephone *T* in line 1 and the extension bell *E* in line 2. If a call comes in over line 2, shift the copper wires so as to connect *a* with *b* and *c* with *d*; then you will have the telephone *T* in line 2 and the extension bell *E* in line 1; and you can talk over line 2 and still get a call if one comes in over line 1 in the meantime. The two copper wires like *y* can be fastened through holes in a thin board, the same size as the block, 4 in. × 4 in., so that it will only be necessary to lift this thin board, turn it one-quarter of a revolution either way, and drop it again so that the ends of the copper wires dip into the mercury in the holes. This will require only an instant. If you prefer, and it would undoubtedly look neater, you can purchase a reversing switch, like the one shown in Fig. 2, that will accomplish the same purpose as the mercury switch. In this figure, the same letters designate the same parts as in Fig. 1. The switch *H* consists of two brass strips *m* and *n* connected by an insulating strip *p* of hard rubber or fiber with a handle at the center. When the switch is over to the left, you have *T* in line 1 and *E* in line 2. When pushed over to the right, *T* is in line 2 and *E* in line 1. If your lines are complete metallic it complicates the connections, requiring really the equivalent of two reversing switches. The arrangement is shown in Fig. 3. The switch *H* has four brass connecting strips, but all should be controlled by one handle. A switch of this kind must be very substantial and well made, or the contacts are liable to give you considerable trouble. If you cannot readily tell which line is calling by the difference in the tone of the two bells, or if you desire to know, after being out of hearing of the bells, whether either have called, use the telephone call indicator illustrated and described on page 410 of the August, 1900, issue of SCIENCE AND INDUSTRY.

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(483) (*a*) I have three Lundell ceiling fans running in series on a 500-volt direct-current circuit. They have been running two seasons without any trouble. Two of them are 115 volt and the other 220 volt. One of them burned out recently. Is it policy to run fans of different voltages in series, and to what do you attribute the above trouble? (*b*) I wish to make several hundred spark coils to be used for igniting gasoline engines. Please give your idea as to the best coil for the purpose, giving dimensions of coil, size of wire, number of layers, etc. (*c*) What are the best acids to use for finishing brass castings for fixtures? I want old gold or bright finish. What will remove dirt and grease from brass, preparatory to finishing? (*d*) Is there any institution in America that will answer questions on electrical subjects by mail? If so, please give name and address.

J. L. D., Lansing, Mich.

ANS.—(*a*) It is not generally a good plan to run motors of different voltages in series across constant-potential mains. The 115-volt motors would have a larger current-carrying capacity than the 220-volt, and a current that would be perfectly safe for them

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might greatly overload the 220-volt motor. Of course, the burn-out may have been due to defective insulation or other causes, hence it is not possible for us to state the cause definitely. (*b*) If you are going to make several hundred coils, we would advise you to look carefully into the matter of dimensions, as it is a point on which there is considerable difference of opinion. It might be worth while to make up a few experimental coils and try them. We assume, of course, that you intend making jump-spark coils, as this is the kind most generally used at present. The following dimensions are recommended by Stoddard: Length of coil, 8 in.; outside diameter, 8¼ in.; diameter of core, 1 in. Primary, 2 layers No. 14 or 16 B. & S. Secondary wound to diameter of 8¼ in. with No. 32 or 36 B. & S. Use six cells of battery. For further particulars, we would refer you to an article in "The Horseless Age," beginning May 23, 1900, on "The Construction of a Jump-Spark Coil," by E. J. Stoddard. (*c*) For dipping brass castings, proceed as follows: First clean the castings of grease and dirt by dipping them in a hot solution of caustic potash *KOH*. Then dip them into hot water. Next dip them into acid made of 2 parts sulphuric acid to 1 part nitric acid, with a slight amount of salt added. If castings come out too red, add more sulphuric acid. If too white, add more nitric acid. Dip as quickly as possible, and then at once plunge into clear water and afterwards dry in sawdust. You can give almost any color you wish to the parts by using different shades of lacquer. (*d*) The International Correspondence Schools, Scranton, Pa., answer questions on electricity by mail when these questions are in relation to the course of study that the student is pursuing. If you desire information on special lines of work, you can obtain it by writing to almost any consulting electrical engineer.

***

(484) I have an induction coil wound for a 5" spark and have tested the same, using a current of 6 amperes at a pressure of 10 volts for the primary. The primary consists of 100 turns of No. 14 B. & S. I find that when I use one condenser of about 2 microfarads capacity, the spark is about 8 in. in length. When I use two condensers, each of the above capacity, and place them in parallel, the spark at the vibrator is naturally diminished, but, contrary to expectations, the secondary spark is also lessened in length. Now, when the condensers are placed in series, giving a capacity of only 1 microfarad, the spark at the make-and-break is, of course, not diminished, but the secondary spark is longer than with either of the other arrangements. (*a*) Is the above due to self-induction? (*b*) Should the current in the primary be increased?

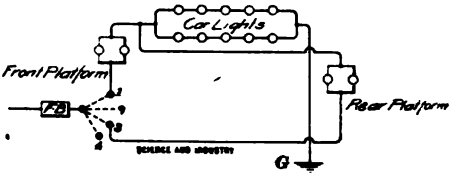
C. J. K., Cincinnati, Ohio.

ANS.—(*a* and *b*) The length of spark that a coil gives depends not only on the strength of the primary current but also on the rapidity with which this current dies away when the secondary circuit is broken by means of the contact maker. The primary always has a certain amount of self-induction that makes the primary circuit act as if it possessed inertia, and this tends to maintain a spark when the circuit is broken. If the spark holds over to any extent, the primary current does not decrease rapidly, and the secondary spark becomes shortened. The capacity tends to neutralize the self-induction, and the current would decrease most rapidly when the capacity was just sufficient to neutralise the self-induction. If more capacity were used, the sparking at the break might be less, but the charging current would prevent the sudden decrease in the core magnetism necessary for a long spark. In this case, it appears that the capacity of 1 microfarad is in better proportion in relation to the primary inductance than the other capacities, hence the longer spark. It must be remembered that if the capacity is adjusted to the best value for a given frequency of the vibrator, it will not necessarily give the best results if the frequency is changed. Increasing the primary current would increase the length of spark to some extent, but would be likely to give rise to trouble at the contact maker.

***

(485) I would like to ask for a diagram of the incandescent lighting circuit as it is used on cars. There are ten lights in the car, and two on each platform. One turn of the switch lights the front platform and all the lights in the car; the second turn extinguishes; the third turn lights the rear platform and all lights in the car, and the fourth turn extinguishes. There are no headlights in connection with the circuit. W. H. M., Buffalo, N. Y.

ANS.—The accompanying figure shows one method of wiring up a car so as to accomplish the above condi-



tions. The switch is connected to the trolley wire through a fuse block *F. B.* A three-point switch is connected as indicated. Putting the switch on point *1* will light the front platform pair of lights and the car lights. The next position will put all the lights out; the third position will light the rear platform lights and the car lights, and the off position will extinguish all the lights. A three-point snap switch adapted for use on a 500-volt circuit should be used.

***

(486) Will you kindly inform me whether the Edison three-wire system of power distribution is at present controlled by patents, or can it be used by any one? W. P. M., Shamokin, Pa.

ANS.—The patents on the Edison feeder and main system, which is used extensively in connection with three-wire distribution, have expired, and we believe the three-wire patents have also expired. We would advise you, however, to consult a patent attorney and find out just what patents relating to the system have become public property, before using it.

***

(487) (*a*) What is meant by the logarithmic decrement of an angle? (*b*) Please give an answer to the following formula, using your own figures:

$$i = \frac{E}{\sqrt{R^2 + \left(\frac{1}{C\omega} - L\omega\right)^2}} \sin\left\{\omega t + \tan^{-1}\left(\frac{\frac{1}{C R \omega} - \frac{L\omega}{R}}{}\right)\right\};$$

$\omega = 2\pi n$, R = resistance also reactance, L = self-induction, C = capacity.

J. B., Central Falls, R. I.

ANS.—(*a*) The term logarithmic decrement is used in connection with the damping effect on the needle of a ballistic galvanometer, and is used in calculating the amount by which the angle or throw of the needle is diminished by damping. The logarithmic decrement is little used in practical work, and a complete explanation regarding it would require more space than we can afford. You will find it explained in Stewart and Gee's "Elementary Practical Physics," Vol. II, p. 367. (*b*) This equation occurs in connection with alternating currents, and gives the value of the current i at any particular instant t, in a circuit containing resistance, self-induction, and capacity. The equation is very sel-

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dom used in practical work, because we are hardly ever concerned with the value of the current at any particular instant. What is usually needed is the virtual or effective value. In this equation, R does not equal the resistance and reactance, as you state. It equals the resistance only. The reactance in this case is equal to $\left(\frac{1}{C\omega} - L\omega\right)$. In order to illustrate the solution we will take the following values: E = maximum value of the E. M. F. = 100 volts; R = 10 ohms; L = .0025 henry; C = 100 microfarads, or .0001 farad; ω = 400; and t = .002 second. We have then

$$i = \frac{100}{\sqrt{10^2 + \left(\frac{1}{.0001 \times 400} - .0025 \times 400\right)^2}} \sin\left\{400 \times .002 + \tan^{-1}\left(\frac{1}{.0001 \times 10 \times 400} - \frac{.0025 \times 400}{10}\right)\right\};$$

$$i = \frac{100}{\sqrt{100 + \left(\frac{1}{.04} - 1\right)^2}} \sin\left\{.8 + \tan^{-1}\left(\frac{1}{.4} - .1\right)\right\};$$

$$i = \frac{100}{\sqrt{676}} \sin\left\{.8 + \tan^{-1} 2.4\right\}.$$

Now, ω is expressed in *radians per second*, hence the .8 appearing in the latter part of the equation is .8 *radian*, and 1 radian = $\frac{360°}{2\pi}$; hence .8 radian = $\frac{360°}{2\pi} \times .8$ = 45° 50′, approximately. The angle whose tangent is 2.4 is about 67° 24′; hence we have

i = 3.85 sin(45° 50′ + 67° 24′)
= 3.85 sin 113° 14′ = 3.85 × .92 = 3.542 amperes, approximately. In substituting in the above equation the capacity C must be expressed in farads, not microfarads.

***

(488) I have a dynamo capable of delivering a current of .5 ampere at a pressure of 4 volts. If I connect a small storage battery and lamp in parallel across the dynamo terminals (lamp requires .5 amp. and 4 volts), will the lamp light up to its full candlepower? If the speed of the dynamo increases, will it charge the battery, and if the speed decreases, will the battery furnish current to light the lamp to full candlepower? E. P. B., Farmington, Conn.

ANS.—If the speed of the dynamo is such that its voltage is higher than that of the battery, the latter will be charged and the lamp will also burn at full candlepower, or somewhat over candlepower, provided the dynamo can furnish the current. You must remember, however, that if the lamp requires .5 ampere and the capacity of the machine is only .5 ampere, the dynamo would probably be much overloaded if you attempted to run the lamp and charge the battery at the same time. If the speed decreased, the battery would run the lamp, but it would also discharge back through the dynamo and run it as a motor if you do not have some means for cutting the dynamo out. We think your best plan would be to charge up the cells by themselves and then use them to operate the lamp, and not attempt to run the two in parallel with such a small outfit as this is.

***

(489) Will you kindly inform me as to where I can purchase a complete outfit for electroplating? I do not care to purchase a large or an expensive one. I would like to experiment and also learn to electroplate as a business venture.
C. H., Edgemoor, Del.

ANS.—You can obtain electroplating supplies of all kinds from Hanson, Van Winkle & Co., Newark, N. J., or from Zucker, Levett & Loeb Co., New York. Either of these firms should be able to equip you with almost any style of outfit you may desire.

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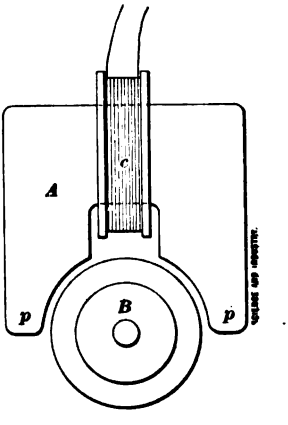
(490) (*a*) Please explain how I can test an armature for short circuits after it is connected to the commutator and before using it on the road. (*b*) I would like to inquire in regard to my question No. 175 in the April number as to how I can test the voltage of the No. 2 motor. (*c*) How is it that when two 500-volt motors are connected in series across a 400-volt circuit and placed on the floor, Nos 1 and 2 will start but No. 2 will slow down and stop while No. 1 will keep on running?
A. F. R., Harrisburg, Pa.

ANS.—(*a*) A method of testing armatures for short circuits was given in the July number of this magazine. Another way is to mount the armature in a field magnet and then excite the field separately while the armature is driven at its normal speed from another motor or any other source of power. If there are any short circuits, the coils containing them will soon get hot and burn out. One of the best methods is shown in the accompanying figure. *A* is a laminated iron core built up to the same length as the core of armature *B*, and provided with polar projections *p*, *p* corresponding to the motor poles. *A* is allowed to rest on the armature core and an alternating current sent through coil *c*. *B* is moved around so as to bring the various portions of the armature under the poles, and if there are any short-circuited coils present, they will soon show it by getting hot. (*b*) Connect the voltmeter directly across the terminals of the No. 2 motor. Of course, if the No. 2 motor does not run, the voltage may be so small that you will have difficulty in reading it. (*c*) In your previous inquiry we supposed that you referred to ordinary shunt-wound motors and not series motors. If two series motors are connected in series across a constant-potential circuit, they are unstable in their action unless they are geared together so that they will both be compelled to run at the same speed. See Answers to Inquiries, No. 395, in the August issue. When the motors are on a car they are compelled to run at the same speed unless the wheels slip, hence they will operate all right and the load will divide between them.



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(491) Will three wires of the calculated capacity of a single one really carry more current, and why?
W. H. B., Villisca, Iowa.

ANS.—We are not sure that we understand the above question correctly, but take it to mean that the single wire has a cross-section equal to the other three combined. For a given rise in temperature the total current carried by the three wires would be greater than that carried by the single wire, because the amount of heat liberated per unit of area, say per square inch, is smaller in case the three wires are used. In other words, the number of small wires allows better radiating capacity. The Underwriters' tables are based on temperature

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rise, and they allow 24 amperes for a No. 10 rubber-covered wire and only 65 amperes for a No. 4, which has four times the cross-section of the No. 10. If, however, you are figuring on a line to give the same drop in voltage in each case, the combined cross-section of the wires in parallel must be equal to the single wire, and the total current must be the same in both cases.

***

(492) Please give directions for making a thermopile that will give 2 or 3 volts. I wish to use sheet iron and sheet copper or lead, and intend to heat it by means of a spirit lamp or gas burner. If it is not possible to use the metals mentioned, what ones can I use? If you cannot give the above directions, please refer me to some book on the subject.

G. S. P., Dorchester, Mass.

ANS.—A thermopile may be made of iron and copper, or iron and lead, but such a pile is not very durable. The iron oxidizes, and there is always more or less danger of melting the lead. The best metals to use are bismuth and antimony, though iron and an alloy of antimony and zinc is sometimes used. Instructions for making a thermopile would take up more space than we have at our disposal; you will find directions for making one in a book entitled, "Electrical Instrument Making for Amateurs," by S. R. Bottone, which may be had from The Technical Supply Co., Scranton, Pa.

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(493) (*a*) Where can I learn the telephone business? (*b*) What is the quickest and best method and what ought I to expect while learning? (*c*) What pay does the manager of an exchange of 200 or 300 subscribers usually receive? (*d*) What is the pay of a telephone lineman or an inspector?

WM. R. L. D., JR., New Petersburg, Ohio.

ANS.—(*a*) Secure a position with some telephone company and take the Telephony Course of The International Correspondence Schools. (*b*) The quickest and best method is to study the subject thoroughly while employed in the business. From $30 to $50 a month. (*c*) From $60 to $80 a month. (*d*) A lineman gets from $2 to $3 a day, according to his ability. An inspector gets from $50 to $80 a month, depending on the size of the exchange and the amount of responsibility given him.

***

(494) (*a*) Will you please give me a method of preventing the oxidation of a wire when brought to about 800° or 900° F. with an electric current? I would rather have it in a paste if possible. (*b*) I would also like to know where I can buy some porcelain enamel. L. L., Quebec, Can.

ANS.—(*a*) You might bed the wire in Portland cement or any other cement that will harden and adhere firmly. Another way would be to wind the wire on an enameled-iron cylinder and cover it with enamel. This latter is a patented process. The wire may be protected for a time by coating it with silicate of soda or water glass, but this covering is not very durable. (*b*) We do not know where you can get this, unless from some porcelain manufacturer. You might try R. Thomas & Sons, East Liverpool, Ohio, or Pass & Seymour, Syracuse, N. Y.

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(495) What metals are used for fuse wire in electric work? A. R., Orange, N. J.

ANS.—There are a variety of metals used for making fuse wire. Ordinary fuses are usually made of a mixture of lead and bismuth, and vary greatly in composition, some fuses being much harder than others. On street cars, No. 12 or 14 copper wire is generally used. For alternating-current work, fuses of aluminum have been used quite largely, and appear to be satisfactory.

BUILDING TRADES

(496) (*a*) Kindly inform me whether the iron truss shown in the enclosed sketch is capable of sustaining safely the load marked on the sketch. (*b*) If not, please state what load it will support safely, and give formulas for computing same.

A. J. J., Worcester, Mass.

ANS.—(*a*) By computing the stresses in the members of the truss shown in your sketch (which is not of sufficient general interest to be reproduced here) that would be caused by the loads marked upon it, considered as either live or dead loads, we find that the cross-sectional area given by each member as marked is sufficient to bear its stress safely. It must be understood, however, that the stresses computed were only those due to the load marked upon the sketch, considering this to be the *total* load upon the truss, including its own weight—not the load that it would bear exclusive of its own weight. However, as the weight of the truss itself would increase the load marked on your sketch by only about one-eighth part, the truss would probably carry safely a live or extraneous load equal to the load marked. What has just been stated has no reference to the details or connections of the members, which are not shown on your sketch. As the capacity of any truss is limited by the strength of its weakest part, our computations do not necessarily show that the truss as a whole will carry the given load safely if any of its details or connections are weak. (*b*) It is impossible to state formulas for determining this. In order to determine this condition, the stress in each of the various members of the truss must be computed and divided by the area of its cross-section. The quotient will be the intensity of the stress per square inch of cross-section, showing whether this is within safe limits. This neglects the increase in resistance due to the rise in temperature.

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(497) (*a*) What are "cooling towers" for, and how are they operated? (*b*) Is it correct to show the roof line dotted in on the third-floor plan of a cottage or other building when it is not desired to show the plan of the roof by itself? (*c*) Was an article on lettering ever published in SCIENCE AND INDUSTRY? If so, when, and where can I get a copy? (*d*) What is the best method of procedure to qualify me to pass the Civil-Service examination for mechanical draftsman in the Patent Office or in the Department of Construction and Repair? (*e*) To get the proper diameters of the joints between the successive rings of a bell-bottom steel stack, I first draw the height of the bell to scale and divide it into equal parts, to represent the number of rings to be used. Through the points of division I draw lines parallel to the base; with a center on an extension of the line representing the top of the bell, I draw the arc of a circle that will pass through the extremities of the lines representing the diameters of the top and the base of the bell. The radii of the joints between the different rings are thus determined by measuring to scale the lengths of the corresponding lines included between the center line of the bell and the arc. Is this an approximately correct method?

R. C. W., Coatesville, Pa.

ANS.—(*a*) Cooling towers are devices for taking the hot water from the condenser of a steam engine, or refrigerating machine, or from any other source, and cooling it so that it may be used again. They are constructed and operated in a variety of ways, but in the most common forms the hot water is allowed to fall in a spray from the top of a tower, while a current of air, induced by a fan, flows upward through the tower. A part of the water is thus evaporated, and the heat required to produce

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the vapor is taken from the rest of the water, leaving it cool enough to be used in the condenser again. By this means the cooling water may be used over and over, the only loss being that due to evaporation in the cooling tower. (*b*) Yes. (*c*) An article entitled "The Alphabet and the Art of Lettering" was published in the May, 1899, issue of the "Mechanic Arts Magazine," and one entitled "Architectural Lettering" in the June, 1899, issue of "The Building Trades Magazine." Copies of these issues may be obtained from The Colliery Engineer Co. The prices of the two issues are respectively 10 cents and 5 cents. (*d*) Address the Civil Service Commission, Washington, D. C., for a copy of the Manual of Examinations; this will give you full information regarding examinations and the amount of preparation required. (*e*) The construction you suggest will give you the correct diameters of the joints for rings of equal heights. If it is desired to make the rings from sheets of equal lengths, more accurate results would be obtained by dividing the arc between the extremities of the diameters of the top and base of the bell into the required number of parts and drawing the lines representing the joints between the rings through these points of division. The chords of the subdivisions of the arc will then represent the lengths of the sheets from center to center of joints, and the parts of the lines representing the joints intercepted between the center line of the bell and the arc will represent the radius of the rings at the joints.

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(498) Enclosed find rough sketch (Fig. 1), showing arrangement of pipes for hot-water system in my house. The tank was at first merely connected with the gas range and then worked to perfection. Last winter I had a plumber connect it with the furnace in the basement. He put in the pipes shown by the dotted lines. Since then, at every attempt to heat the water with the gas range, a tremendous

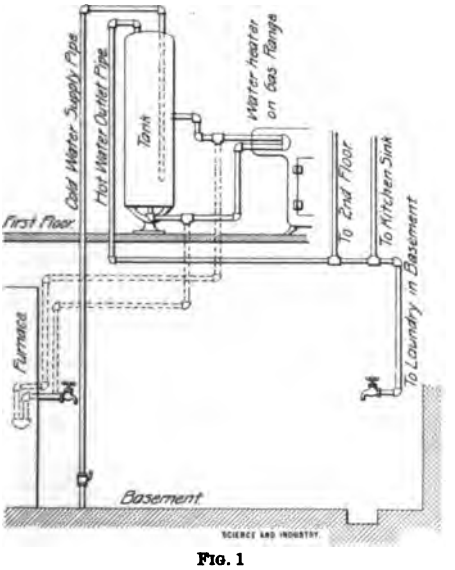
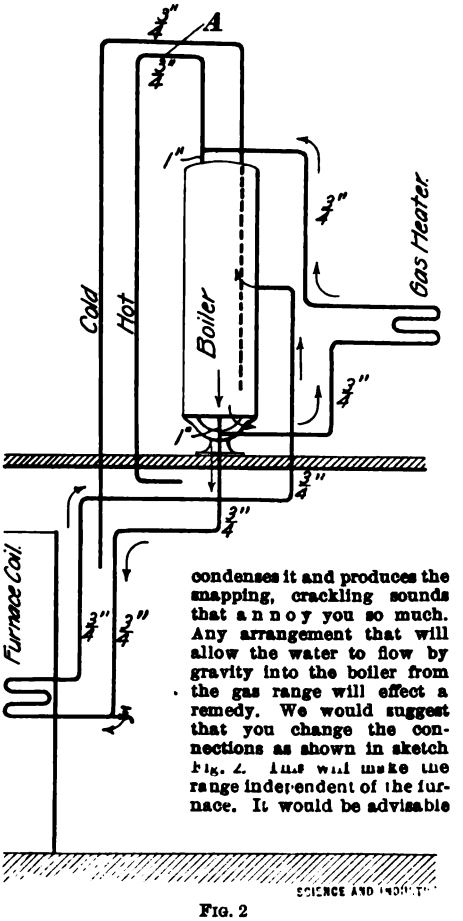


FIG. 1

thumping occurs in the tank, so violent that we are compelled to turn out the gas in the range, for fear of an accident. Please inform me as to the cause and remedy. R. B. P., Cleveland, Ohio.

ANS.—Your trouble is due to the fact that the "head" for circulation that existed between the gas heater and the boiler is spoiled by the new pipe connections. There is therefore no force present to produce a circulation between the gas heater and the boiler, no matter how hot the water in the gas heater may become. In fact, a good proof of this is found when you light the burners under the gas heater, for it makes steam, which, expanding toward the boiler, encounters a colder body that rapidly



condenses it and produces the snapping, crackling sounds that annoy you so much. Any arrangement that will allow the water to flow by gravity into the boiler from the gas range will effect a remedy. We would suggest that you change the connections as shown in sketch Fig. 2. This will make the range independent of the furnace. It would be advisable

FIG. 2

to make the connections between the branches and the boiler 1 inch, as shown. The arrows show the direction of the circulation of the water through the boiler, furnace, and gas heater. By connecting your boiler as shown in our sketch you will be able to draw hot water at the fixtures before the boiler is heated, which is a great saving of money and time. The boiler in our sketch acts only as a reservoir to store hot water, and not as a mixing device for cooling it until the whole boiler has time to become hot. If it is possible, we would advise you to supply the wash basin upstairs with a hot-water branch taken from the highest point *A*, so that air which surely will accumulate there may be drawn off at the basin. If you cannot do this, then raise this loop as high as possible, so that it will become a large air-storage chamber, which will be filled with water every time hot water it drawn at the kitchen sink.

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(499) In building a wooden tank 16 ft. in diameter and 16 ft. high, to hold water, the tank being built of pine staves 3 in. thick, with 3/" iron bands spaced 15 in. from center to center, (a) how thick should the bands be, and how much heavier at the bottom than at the top? (b) what are the rules for calculating the dimensions of the bands by the use of arithmetic? B., Port Henry, N. Y.

ANS.—(a) There are two factors to be considered in estimating the strength of bands required for such a tank. The first is the pressure due to the head of the water, and is easily calculated. The second depends on the amount of force exerted by the swelling of the staves when wet, and for this we have no reliable data at hand. Estimating this force at 400 lb. per sq. in. for the material of which the staves are made, the 3/" bands should be about ⅜ in. thick at the bottom and ¼ in. thick at the top. (b) The stress in the bands due to the head of the water is found by multiplying the head in feet, measured from the surface to the center of a band, by .434, this product by the diameter of the tank in inches, and the product so obtained by the distance in inches from center to center of bands; divide the last product by 2, and the result will be the stress in any section of a band due to the head on it. To find the stress due to the swelling of the staves, multiply the thickness of the staves by the distance from center to center of the bands and by the pressure per square inch due to the swelling of the wood; the product will be the stress in any section of a band due to the swelling of the wood. At the surface of the tank the only stress will be that due to the swelling of the staves. For any band below the surface, the stress will be that due to the swelling of the staves plus that due to the head of water on the band. When the total stress in a band is determined, the thickness of the band is found by dividing the total stress by the width multiplied by the allowable unit stress. In our estimate, we assumed an allowable unit stress of 12,000 lb. per sq. in.

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(500) Please explain the use of the dots and numbers (5, 10, 15) between two parallel lines on the short leg of a steel square; also the use of the ten parallel lines about two inches long and the ten diagonal cross-lines near the angle of the square on the other side of the short leg. W. H. B., Villisca, Iowa.

ANS.—The required explanation is too lengthy to give in these columns. The information is given in an article entitled "The Steel Square," which appeared in the September, 1899, issue of "The Building Trades Magazine." This magazine may be obtained from The Colliery Engineer Co., Scranton, Pa., for 10 cents.

MISCELLANEOUS

(501) How can I make a standard solution of silver nitrate with which to determine the percentage of potassium cyanide in a solution? W. E. L., Folts, Nev.

ANS.—A rapid and accurate determination may be made by titrating a measured quantity of the solution to be tested with a standard solution of silver nitrate. Silver cyanide is formed and immediately redissolves in the excess of potassium cyanide. The end reaction is reached when a permanent white precipitate of silver cyanide is formed. When silver nitrate is first added to a solution of potassium cyanide a precipitate of silver cyanide is formed, and this dissolves in the presence of any free potassium cyanide. The silver nitrate is added until all of the potassium cyanide has united with the silver cyanide to form a double salt of potassium silver cyanide. If more silver nitrate is added than is required to form the double salt, a permanent precipitate is formed of silver cyanide, which shows that sufficient silver nitrate has been added for the reaction. The end reaction is more distinct when two or three drops of a 5-per-cent. solution of potassium iodide are added to the cyanide solution before titration. After all the cyanide is converted into the double salt, any excess of silver nitrate will unite with the potassium iodide to form a precipitate of silver iodide. A convenient standard solution is one that contains such an amount of silver nitrate in each cubic centimeter that when it is added to 10 c. c. of a cyanide solution before a permanent precipitate is produced, represents 0.1% of potassium cyanide. To do this, take 13.06 grams of silver nitrate and dissolve it in exactly 1 liter (1,000 c. c.) of distilled water. The determination is carried on as follows: (1) Fill the burette with the standard silver nitrate solution. (2) Fill another burette with the cyanide solution to be tested. (3) Run into a beaker 10 c. c. of the cyanide solution and add 25 c. c. of distilled water; from the silver nitrate burette cautiously add silver nitrate solution until a permanent opalescent precipitate remains after thoroughly agitating the solution. Two or three drops of a solution of potassium iodide, added to the beaker when the cyanide solution is added, will assist in determining the end reaction. (4) Read the number of c. c. of standard silver nitrate used and divide by 10; the result is the potassium cyanide in the solution in per cent.

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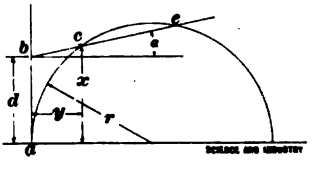
(502) Please show how to find the distance x in the diagram. E. C. D., Pittsburg, Pa.

ANS.—Assume a as the center of coordinates. Then, by the principles of analytic geometry, the



equation of the line be is $x = y \tan \alpha + d$; and the equation of the circle, referred to a as a center, is $x = \sqrt{2ry - y^2}$. As the line and circle intersect, they have common coordinates for the points of intersection; hence, the values of x may be equated thus: $y \tan \alpha + d = \sqrt{2ry - y^2}$. Squaring, transposing, and collecting terms,

$$y^2(1 + \tan^2 \alpha) - y(2r - 2d \tan \alpha) = -d^2.$$

Noting that $1 + \tan^2 \alpha = \sec^2 \alpha$, there results, on completing the square and solving for y,

$$y = \frac{r - d \tan \alpha \pm \sqrt{(r - d \tan \alpha)^2 - (d \sec \alpha)^2}}{\sec^2 \alpha}.$$

This gives two values for y, one corresponding to point c, and one to e. For e the radical term is subtractive. Having found y, $x = y \tan \alpha + d$.

***

(503) (a) How do linotype machines work, and what do they do? (b) Who manufactures these machines? (c) Where can I obtain a book describing their workings and explaining how to adjust them and correct their faults? J. H. F., Taunton, Mass.

ANS.—(a) A linotype is, strictly speaking, a typecasting machine, and is operated by a keyboard. Channels in a magazine at the highest point of the

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machine contain matrices, which are strips of brass a little more than an inch in length and just thick enough to allow the impression of a letter to be sunk on the edge of each one. By operating a keyboard similar to that of a typewriter, the matrices are assembled one by one until the desired length of line is filled. The spaces between words contain what are called space bands, which are adjustable wedges that regulate the spaces between the words to make the lines uniform in length. After a line has been assembled the operator throws a lever and this line of matrices is carried into a casting box, into which metal is injected and a line of letters thus cast. The matrices are then carried by a series of arms to the rear of the magazine, where they are dropped into their respective channels by a combination bar. The whole operation of the machine is automatic, with the exception of the manipulation of the keyboard and the throwing of the lever when a line has been assembled. (*b*) The Mergenthaler Linotype Co., Tribune Building, New York City. (*c*) The manufacturers issue a book of instructions, but this is more suitable for those who have had considerable experience with the machine. The only other books that we know of on this subject are "The Linotype Operator's Companion," by Barclay, price $1.00, and "The Mechanical Details of the Linotype, and Their Adjustment," by Evans, price $3.00, which are books more suitable for beginners than those issued by the manufacturers. These books may be ordered through The Technical Supply Co., Scranton, Pa.

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(504) In the May number of SCIENCE AND INDUSTRY there is a description of a lead-burning machine. (*a*) Are there many lead burners in the United States? (*b*) Is there any institution or school that teaches lead burning? (*c*) In what kind of works is lead burning principally done? (*d*) What is the average wage of a good lead burner? (*e*) Are there other methods of burning lead than by the hydrogen-gas method? B. F., Alpena, Mich.

ANS.—(*a*) No; the demand for lead burning is not sufficiently great to warrant the existence of a large number of lead burners. (*b*) Yes; manual instruction in lead burning is given in the New York Trade Schools. The theory and the practice of lead burning is also taught as a portion of the Plumbing Course in The International Correspondence Schools, Scranton, Pa. (*c*) In chemical works and other manufacturing establishments where chemicals are stored in tanks and vats or conveyed by pipes or conduits, or otherwise handled in large quantities. (*d*) Somewhere in the vicinity of $5 a day. (*e*) Yes, you can burn lead in a small way with an ordinary gas and air blowpipe, provided that you have the proper kind of a tip. Yeager salts is commonly used with such a blowpipe. The method is too extensive to be fully explained here, but for further information we would refer you to T. B. Walmsley, Wood Cliff, Bergen Co., N. J., the manufacturer of this blowpipe.

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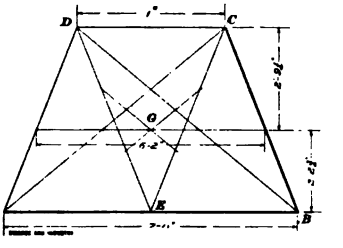
(505) The enclosed drawing represents the elevation of a tank. The tank is 4 ft. long on top, 7 ft. 11 in. long on bottom, and 5 ft. high. (*a*) When the tank is half full of water, how high does the water rise? (*b*) I found *G* the center of gravity of the vertical section as shown, and found the area of the part below *G* to be 2,260.375 sq. in., and the area of the part above *G* to be 2,028.25 sq. in. These two parts are not equal, and their sum is 4,288.625 sq. in., whereas the area of the whole section is 4,290 sq. in. What is the error in my solution?

R. C. D., Rossland, B. C.

ANS.—You do not give a horizontal section of the tank, nor do you state what is the shape of the top or bottom. The depth of the water, however, will be the same whether the tank is a frustum of a cone or a frustum of a pyramid whose top and bottom are similar polygons. Reduce all dimensions to inches, and let h = height of tank, and x = depth of water when $\frac{1}{n}$ part of tank is filled. For a conical tank, let R = radius of bottom, and r = radius of top. If the tank is a frustum of a pyramid whose top and bottom are similar polygons, R will denote the length of one side of the polygon that forms the bottom, and r will denote the corresponding side of the polygon that forms the top; h and x have the same meaning as in the case of a conical tank. Then x is given by the formula

$$x = \frac{h\left[R - \sqrt[3]{\frac{(n-1)R^3 + r^3}{n}}\right]}{R - r}.$$

Putting $n = 2$, $R = 47.5$, and $r = 24$ in this formula, we get $x = 21.05$, nearly. Thus, the depth of the water when the tank is half full is 21.05 in. = 1 ft. $9\frac{1}{16}$ in. (*b*) Your construction for the center of gravity of the vertical section shown in the figure is not correct, for the line *C E* does not bisect the line *B D*, nor does the line *D E* bisect the line *A C*. Therefore, the center of gravity of the triangle *D B C*



does not lie on the line *C E*, nor does the center of gravity of the triangle *A C D* lie on the line *D E*. You can satisfy yourself by scale measurement that *C E* does not bisect *D B*, and that *D E* does not bisect *A C*. Then you can correct your construction for the center of gravity by locating the center of gravity of the triangle *D B C* on the line drawn from *C* to the middle point of *B D*, and the center of gravity of the triangle *A C D* on the line drawn from *D* to the middle point of *A C*. If the line *A B* were equal to twice the line *D C*, your construction for the center of gravity would be correct; for, in this case, *C E* would bisect *B D* and *D E* would bisect *A C*. Because the line *A B* is very nearly double the line *D C*, the point *G* found by you is very close to the true center of gravity of the vertical section. No matter whether *G* is the center of gravity or not, the area below *G*, added to the area above *G*, is equal to the whole area of the vertical section. But your determination of the distances of *G* from the top and bottom and of the length of the horizontal line through *G* are only approximately, and not exactly, correct; this is the reason that you did not find the sum of the areas above and below *G* equal to the whole area of the vertical section. Let *O* be the true center of gravity of the vertical section *A B C D*; then, it is not true that the area above *O* is equal to the area below *O*. Moreover, *O* is the center of gravity of the vertical section *A B C D*, but *O* is not the center of gravity of the tank. If you did find the center of gravity of the tank, the volume above that center of gravity would not be equal to the volume below it.

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(506) (*a*) If a survey does not "close," how are the courses balanced so as to make it close? (*b*) What is the best method of plotting the boundaries of a closed survey? (*c*) Explain a method for cor-

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recting the error of closing without calculation. (*d*) Explain clearly the graphical method of balancing a land survey. (*e*) What are the principal causes of error in the measurement of the angles of a survey? (*f*) What check can be had on such errors? (*g*) What are the chief causes of error in linear measurement? J. W. L., New York City.

ANS.—(*a*) If a survey does not "close," that is, if when the courses are plotted successively and accurately to any scale, the end of the last course as plotted does not coincide with the beginning of the first course, it shows either the existence of error in one or more of the bearings or angular measurements or the lack of uniformity in the linear measurements. If the angular measurements are correct and the linear measurements are *uniform*, whether uniformly correct or uniformly erroneous as if made with a chain of erroneous length, it is evident that the survey will *close*, although the area as thus obtained will be incorrect. When the plot of a survey does not close, the following rule is very commonly applied: *As the sum of all the distances is to the length of each particular course, so is the total error in latitude* (*or departure, as the case may be*) *to the corresponding correction for that course.* The correction for each course must be so applied as to diminish the error. This rule merely distributes the error of closure uniformly throughout the survey, assuming it to be due both to erroneous bearings or angular measurement, and erroneous chaining, which is seldom likely to be the case exactly, though the condition may be approximated in needle-compass surveys. But when the bearings are taken accurately with a solar instrument, or the angles are measured accurately with a transit, the error of closure would be due almost or quite wholly to erroneous chaining. In such cases the following rule may be used: *As the arithmetical sum of all the latitudes* (*or departures, as the case may be*) *is to the latitude of any particular course, so is the whole error of latitude to the correction to the latitude of that course.* It will be evident that this rule also merely distributes the error, though in such manner as to effect the corrections in the lengths of the lines chiefly. (*b*) By latitude and departure. (*c*) The conditions under which the measurements are made are not usually uniform throughout a survey, but are such as to render the process of measuring much more difficult in some parts of the survey than in others. For example, some portions of the plot surveyed may have been much rougher than other portions, or the weather may have been more favorable during some portions of the survey than during others, or for some reason certain portions of the measurements may have been made more carefully than other portions, etc. In such cases the surveyor, by going over his notes carefully and correcting and adjusting them according to the best of his judgment, can probably balance the survey more correctly, that is, in a manner corresponding more nearly to the actual facts of the case, than can be done by means of any mathematical rule. The theory of this method is to, so far as possible, *make the corrections where the errors were made*, which is certainly an excellent theory and one that can be applied with excellent results in many cases. For the surveyor who performs the work can usually judge with reasonable accuracy of the portions of the survey in which the errors are most likely to have been made, and somewhat also of the general character and approximate amounts of the errors. (*d*) The following graphical method of balancing a survey is published in Trautwine's "Engineers' Pocketbook," by which it is an easy matter to distribute the error of closure throughout the survey, obtaining substantially the same result as by applying the rule first stated above. The following explanation will be understood without being illustrated by a figure: Plot the survey accurately from the notes of the field work. If the plot does not close, draw a closure line from the end of the last course to the beginning of the first course as plotted, and draw a line parallel to this through each angle of the plot. The first-mentioned line will represent the error of closure in both magnitude and direction. Lay off on each of the parallel lines a distance from the angle which, as compared with the length of the closure line, will be proportional to its distance from the beginning of the survey, and join the points thus determined. The lengths and bearings of the new lines thus obtained can be found approximately by measurement. The proportional distances to be laid off from the angles on the parallel lines can be determined graphically as follows: Draw a straight line having a length to scale equal to the aggregate length of all the courses and lay off the lengths of the courses in order upon it, and through each point thus determined draw a short line perpendicular to it. On the last perpendicular, erected at the point corresponding to the terminus of the last course, lay off the error of closure, that is, the length of the line representing the error of closure, and draw a straight line joining the point thus determined with the beginning of the line first drawn. The distances on the perpendicular lines between the two diverging lines will be the proportional distances to be laid off on the parallel lines from the angles of the plot. (*e*) Inaccuracies in the graduations of the instrument used, imperfect adjustment of the instrument, including the instrumental parallax due to the inaccurate focussing of the objective, unfavorable atmospheric conditions, such as varying refraction or the unsteadiness of the air from the heated air-currents, error of parallax in reading the vernier, haste and carelessness in reading and recording the angles, recording angles to the right that are turned to the left and vice versa, the "personal equation" or errors that are peculiar to the person observing, and a number of minor causes that may be operative in particular cases. These relate to angular measurement, properly so called. In taking bearings with a compass there is much liability to error from local attraction, inaccurate reading of the needle, inaccuracy in the mounting of the needle, and sluggishness of the needle due to the wearing of the pivot. (*f*) A rough but valuable check on the reading of angles is given by the simultaneous reading of the needle. But the most valuable check is to be had by repeating the angles according to some definite system, such as turning the angle forwards on the limb a certain number of times by repeated observations taken in such manner as to add the readings accumulatively, and then divide the total angle turned off by the number of repetitions; then reverse the telescope and repeat the entire operation in the opposite direction. Where exceedingly accurate results are required, the observations should be made only on densely cloudy days or after four o'clock in the afternoon on clear days, or in the night time when circumstances will permit. (*g*) Inaccuracies in the length of the chain or measuring instrument, lack of proper alinement in the measurement, failure to always hold the measuring instrument perfectly level, failure to have it always under a uniform tension and to compensate for variations in temperature, effect of a cross-wind, especially on a steel tape, or effect of a longitudinal wind on a plumb-line in measuring up or down hill, carelessness or lack of uniformity in setting the points, and again the "personal equation" and many other minor influences. More or less of these conditions must be taken into consideration and provided against, according to the degree of accuracy required.

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SCIENCE AND INDUSTRY

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REVOLVING STORMS

Ernest K. Roden

CHARACTERISTIC FEATURES OF CYCLONES—REGIONS AND SEASONS IN WHICH THEY OCCUR. INDICATIONS OF THEIR APPROACH—THE STORM WAVE

THE attention of the civilized world, and particularly the United States, has this year been called to the disastrous effect of the great atmospheric disturbances generally known as West Indian hurricanes, one of which, on September 8, struck the city of Galveston and within a comparatively short time reduced the whole of that community to a veritable mass of ruins and caused the death of several thousands of its inhabitants. The details of this most lamentable tragedy of modern times has been described very minutely by the American as well as the European press, and a repetition of the horrors attending this outburst of Nature's rage is therefore not within the scope of this article. The writer, however, feels confident that to many, whose memory is still fresh with the Galveston disaster, a brief review of the nature and peculiarities of revolving storms will prove both interesting and instructive, and therefore presents to the reader a few facts about these storms, not from the standpoint of the professional meteorologist, but from the point of view of a practical navigator.

Revolving storms are known under various local names. In the West Indies and in southern parts of the United States they are known as hurricanes, while in the Indian Ocean and the China Sea they are termed typhoons. They may, however, be classed under the general term of cyclones, owing to the more or less circular direction of the winds that constitute them.

Among the characteristic features by which these storms may be distinguished from the ordinary straight-line gales, the following are prominent:

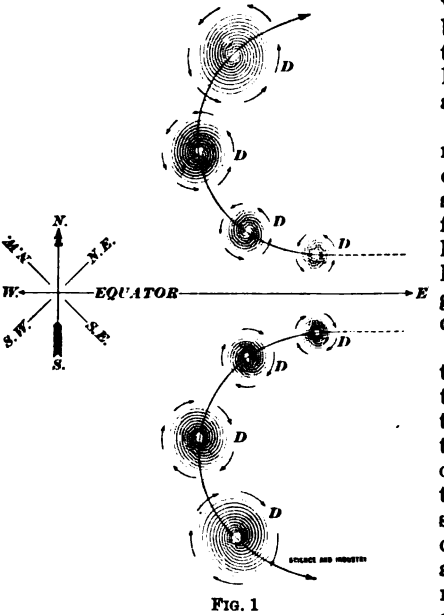

FIG. 1

1. They have a rotary motion around a center, or focus, and a progressive motion varying from 4 to 15 miles per hour; the latter motion, however, depends, to a great extent, on local circumstances.

2. The peculiarity of their rotary motion is that in each hemisphere the rotation invariably takes place in different directions. Thus, in the northern hemisphere, the rotation is contrary to the hands of a watch, that is, from right to left; in the southern hemisphere the rotation is with the hands of a watch, or from left to right.

3. The shape of a cyclone is seldom circular, but rather oval or elliptical, and its diameter, which is generally very small at its origin, expands with the increase in latitude to as much as 800 or 1,000 miles.

4. In all cases within the tropics they

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commence to the eastward. For some days they travel slowly along a path not exactly west but inclining a point or two toward the pole of the hemisphere in which they begin; as they advance they seem to be more inclined to curve away from the equator, and when they reach the 25th to 30th parallel of latitude they generally curve still more, at the same time increasing their progressive motion, until they move in a northeasterly direction in the northern hemisphere and in a southeasterly direction in the southern hemisphere, as shown in Fig. 1. But some cyclones seldom or never recurve; thus, the cyclones of the Bay of Bengal move, according to the season, from east to west or from south-southeast to north-northwest. The typhoons of the China Sea are of both types. Hurricanes also traverse the northern part of the North Atlantic Ocean from west-southwest to east-northeast without having recurved, as did the hurricane of October 20–23, 1897 (indicated in diagram of Fig. 2, by the curve numbered *21*). Similarly, the progressive motion of cyclones in the Southern Pacific Ocean are sometimes east-southeast and southeast, forming areas of low pressure, amalgamating as they pass onward, and then finally dispersing. As previously stated, the progressive motion is governed by local circumstances, but the rate of this motion has no necessary connection with the force of the wind.

The accompanying diagram, Fig. 2, compiled by the United States Hydrographic Office, shows the path followed by the center of each of the tropical cyclonic storms that have occurred in the North Atlantic Ocean during the ten-year period 1890–99, the indicated points in each track marking the position of the storm center at Greenwich mean noon of successive days, the intervals between these points thus showing the distance traversed by the storm center during approximately 24 hours. The dates of the several storms are as follows:

1.	Aug. 27—Sept. 1, 1890	14.	Oct. 24—Oct. 27, 1894
2.	Aug. 19—Aug. 25, 1890	15.	Oct. 18—Oct. 25, 1895
3.	Aug. 19—Aug. 31, 1891	16.	Sept. 5—Sept. 10, 1896
4.	Sept. 4—Sept. 9, 1891	17.	Sept. 19—Sept. 25, 1896
5.	Sept. 16—Sept. 25, 1891	18.	Sept. 26—Sept. 29, 1896
6.	Sept. 28—Oct. 7, 1891	19.	Oct. 9—Oct. 14, 1896
7.	Aug. 17—Aug. 22, 1892	20.	Oct. 23—Oct. 26 1897
8.	Aug. 15—Aug. 22, 1893	21.	Oct. 20—Oct. 23, 1897
9.	Aug. 23—Aug. 28, 1893	22.	Sept. 11—Sept 20, 1898
10.	Sept. 6—Sept. 9, 1894	23.	Aug. 3—Aug. 25, 1899
11.	Sept. 20—Oct. 4, 1894	24.	Aug. 30—Sept. 7, 1899
12.	Oct. 5—Oct. 10, 1894	25.	Sept. 8—Sept. 14, 1899
13.	Oct. 12—Oct. 18, 1894		

5. The atmospheric pressure is lowest at the center of the cyclone (often 28 inches or less) and gradually increases toward the circumference, while the velocity of the wind is greater nearer the center.

6. The winds within a cyclone do not blow in perfect circles nor in straight lines, but rather in irregular spirals. They blow in a more circular direction on the outside of the cyclone than near its center. A cyclone, therefore, must not be thought of only as a rotating disk propelled mechanically from parallel to parallel, but also as an atmospheric eddy (see Fig. 3), which dies out in its rear but is rapidly renewed in its front.

7. Tropical cyclones are never met with in the belt between 10° N. and 10° S., but outside of these limits they occur in the following regions:

North Atlantic—Western part, in the vicinity of the West Indies and along the southeast coast of the United States.

South Atlantic—Southern part.

North Pacific—The China and Java Seas and the coast of Japan.

South Pacific—Eastern part.

North Indian Ocean—Bay of Bengal and Arabian Sea.

South Indian Ocean—Near Mauritius and Reunion Islands.

Cyclones are little known in the South Atlantic and South Pacific Oceans. In the latter, they are but occasionally met with in the region east of Australia. In the northern gulfs of the Indian Ocean, particularly in the Bay of Bengal, cyclones occur with dreaded violence.

8. Years of diligent observations have established the fact that the most cyclone-infested regions of the globe are the West Indies, the Arabian Sea, and the China Sea. The worst cyclone months in the various regions are given as follows:

West Indies—June to October, particularly August and September.

South Atlantic—December to February.

Bay of Bengal and Arabian Sea—April, May, October, and November.

South Indian Ocean—January to March.

China and Java Seas—July to October.

The foregoing paragraphs will give the reader a general idea of revolving storms.

Let us now go a little further into this quite interesting subject and make a brief survey of the storm area itself.

From the nature of cyclonic storms it is evident that the wind in the front and rear must be in a direction perpendicular to the line of progression *a b*, Fig. 3, or nearly so; in other words, if the cyclone is moving in a north-northeast direction the wind in its

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front should be about east-southeast, and in the rear about north-northwest. From this an important conclusion may be drawn, namely, if we assume the area of the cyclone to be divided into two equal parts by the line of progression $a\,b$, and another line $e\,d$ is drawn through the center c perpendicular to $a\,b$, the front quadrant $b\,c\,d$, in which the wind blows toward the line of progression, or track of center, is the most dangerous part of the cyclone, with the exception of the center itself. The rear quadrant $a\,c\,d$ may also be considered dangerous because the direction of the wind will tend to carry a vessel that may happen to be there into the front quadrant and thence in the path of the center. These two quadrants, or the semicircle $a\,d\,b$, is therefore known as the *dangerous semicircle*, and the other half $a\,e\,b$ as the *navigable semicircle*, since the wind in the latter will blow away from in front of the cyclonic center. These two semicircles change sides in different hemispheres, the dangerous semicircle always being to the right of the line of progression in northern latitudes and to the left in southern latitudes. It will be noticed by examining Fig. 1 that in both cases the dangerous semicircle (denoted by D) is on the inner side of the curved track. From the foregoing conclusions rules have been drawn up for the use of navigators to enable them to determine on which tack a ship should be laid-to when confronted with a storm of cyclonic character, the object of these rules being to prevent the wind from veering by the ship's head and to insure its veering or shifting constantly farther aft so that she may be constantly "coming up" to the wind, whereas in the former case she would be "breaking off" from the wind, and, even with no sails set, would, in so violent a gale, be in danger of being driven astern. All positive rules, however, are, of course, more or less defective, and if blindly carried out may prove dangerous. The rules are, nevertheless, of great value when judiciously used in combination with a good judgment of prevailing circumstances. The first thing to be done when a navigator has good reason to believe a hurricane is approaching is to find the bearing of its center and then to shape his course so as to avoid it. The question then naturally arises, When is there a good reason to believe a hurricane is approaching? The best general information on this subject is undoubtedly that given by the Hydrographic Office and printed on charts that embrace cyclone-infested regions, particularly the chart of the North Atlantic Ocean dealing with West Indian hurricanes. Part of these notes are reproduced here, and they will prove of great interest and usefulness not only to the navigator but to all inhabitants of coast cities, towns, and villages situated within the regions through which cyclones usually pass.

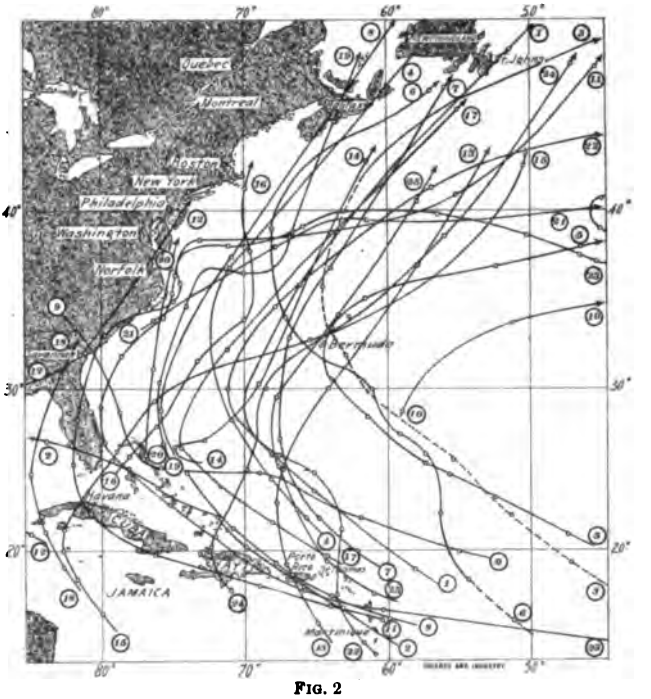

FIG. 2

The earliest indications of an approaching hurricane are as follows: Barometer above normal, with cool, very clear, and pleasant weather; a long, low ocean swell from the direction of the distant storm; light feathery cirrus clouds, radiating from a point on the horizon where a whitish arc indicates the bearing of the center. Unmistakable signs of the storm are: falling barometer; halos about the sun and moon; increasing ocean

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swell; hot, moist weather, with light variable winds; deep red and violet tints at dawn and sunset; a heavy mountainous cloud bank on the distant horizon; barometer falling rapidly, with passing rain squalls. If from the cloud bank shreds of clouds are

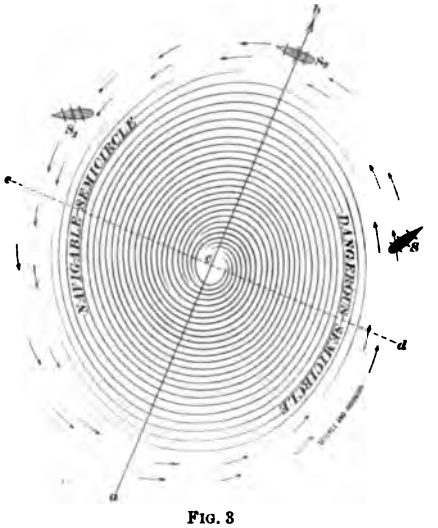

FIG. 3

seen projected forward and upward, as if by some violent ascensional movement of air, the storm center is dangerously near.

But perhaps the most timely and trusty indication of a cyclone is often the rise of the thermometer in connection with a reversal of the normal wind. Thus, in the regions of the trade winds, a brisk westerly wind suddenly springing up should at once arouse suspicion, particularly in the hurricane season. Equally suspicious is a strong easterly wind suddenly succeeding the normal westerly winds prevailing between 35° and 40° N. on the routes between the United States and Europe. Scarcely anything except the indraft of a deep depression can be supposed to cause the sudden change of the trade winds and the East Indian monsoon in August and September. A cautious navigator, therefore, may, by attending to the abnormal and sudden change of wind direction, foresee that he is in front of a revolving gale though his barometer remains high, the sea smooth, and none of the usual signs of a hurricane can be distinguished overhead. Being convinced that the approaching storm is of a cyclonic character the bearing of its center is determined. This is done by facing the wind, in which position the center may be assumed to bear ten points to the observer's right in northern latitudes and ten points to the left in southern latitudes. If, however, the ship has already got into the gale, the center may be less than ten points, say eight or nine points. Having the approximate bearing of the storm center, the next thing to do is to find the position of the ship in relation to the track, or line of progression, of the storm. This can be determined by the shifting, or veering, of the wind. In the northern hemisphere, if the wind shifts to the right, the ship is to the right of the track, as at S, Fig. 3, or in the dangerous semicircle; if it shifts to the left, the ship is to the left of the track, as at S_1, or in the navigable semicircle. These conditions are reversed in the southern hemisphere. But if the wind is steady, shifting but very slightly and increasing in velocity, it indicates that the ship is on the track and in front of the storm center, as at S_2, Fig. 3. When a ship is well within the area of a hurricane, the *approach* of the center is indicated by rapidly falling barometer, increase of wind velocity, heavy squalls, intense lightning and rain in combination with a heavy confused sea and continued shifting of the wind except when on the line of progression. The *receding* of the center is usually indicated by a rising barometer, more steady wind, decreasing in force, weather clearing, but the sea confused and dangerous. When the bearing of the center and the ship's position in reference to the line of progression have been determined, the following rules should be adhered to as far as circumstances permit:

If on the track of the storm center in front of the advancing storm, run or steam before the wind until clear of the track; then lay-to on the port tack, if obliged to. If in the dangerous semicircle, steam or run off with the wind on the starboard quarter; if obliged to lay-to, do so on the starboard tack. If in the navigable semicircle, steam or run off with the wind on the starboard quarter; if obliged to lay-to, do so on the port tack.

These rules apply to the northern hemisphere and to cases where hurricanes are encountered in the open sea. If, however, the vessel is unable, from want of sea room, to perform the necessary maneuvers, her position becomes one of great danger. Every precaution should then be taken to prepare for the passage of the storm center over the ship. In entering the center, which may be several miles in diameter, the wind suddenly ceases and glimpses of a clear sky can be seen now and then, interrupted by puffy

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squalls. The sea is high and very dangerous, apparently coming from all directions of the compass. After the center has passed over, the ship is again struck by a gale of renewed energy and hurricane force, but from the *opposite* direction. This constitutes one of the most critical dangers known to seamen. The best thing to do, it seems, when caught in the center of a hurricane, is to try to get the vessel in such a position as to best meet the opposite wind, which may be expected to burst forth very quickly and violently, and thereby prevent the ship from gathering sternboard, or drifting backward in a helpless position with enormous seas breaking over her. Only strongly-built vessels are able to withstand the heavy strain they are subjected to under such circumstances, and many ships whose names now figure on the list of "missing" in all probability met their fate in the center of a revolving storm.

In connection with hurricanes, it must be borne in mind that although the region and season of the year would render the navigator cautious, yet every strong wind or gale met with, particularly in the tropical regions, must not be treated as cyclonic. When there is reason to suspect the advance of a cyclonic storm, the safest proceeding is to lay-to and carefully watch the barometer, and note the appearance of the weather and the shiftings of the wind. A decided drop of the atmospheric pressure of at least half an inch, together with marked shiftings of the wind, should be experienced before it can be concluded that the storm is cyclonic.

So much for the danger arising from the great velocity of wind and the heavy sea produced by such wind. But wind is not the only destructive element accompanying a cyclone. Another danger is the "storm wave" that, so to speak, follows the wake of the storm center and at times completes the work of destruction.

The storm wave is of no particular importance to ships that have plenty of sea room; it is the coast cities and fishing communities situated on low land that will feel its effect when struck by a hurricane advancing from off-shore. This was particularly the case at Galveston. The wind alone would never have caused such loss of life; it might have wrecked a great many less substantially constructed buildings and thereby caused the death of a considerable number of the inhabitants, through their inability to escape from the strange fate of being buried in the ruins of their own homes, but such high figures as are now written on the death list of Galveston would never have been reached by the agency of the wind alone. It was that dangerous ally of the wind, the storm wave, that ran these figures up so high.

By "storm wave" we mean the wave raised by the wind and the atmospheric condition of the hurricane, which, by many, is erroneously termed the "tidal wave." It should be understood, however, that the storm wave has necessarily no connection with the phenomenon of tides although it may, under certain circumstances, be affected by it. How this storm wave, which hitherto has been given but slight attention, except for its effect, is produced may possibly prove of interest. It is a fact well known to students of tides and tidal phenomena in general that the atmospheric pressure has a marked effect on the height of tides. When the barometer is low the tides become higher than under normal atmospheric conditions; in other words, a low barometer, or, what is the same thing, a less pressure, will produce a higher tide. Applying this theory to cyclones, the cause of the storm wave is readily understood. As previously stated, the atmospheric pressure at the storm center is considerable less than outside of the storm area; consequently, the equilibrium of the water being disturbed by unequal pressure, it will be heaped together and rise at the place of least pressure, which is at the center of the hurricane, as shown

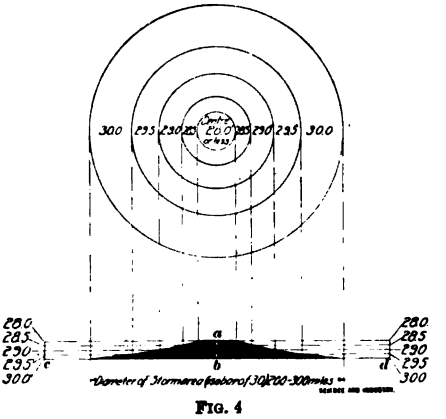

FIG. 4

in Fig. 4, where the inner circle of the upper diagram represents the storm center with an atmospheric pressure of 28 inches or less, and the line $a\,b$ in the lower diagram represents the height of the storm wave above the normal surface $c\,d$ of the water corresponding to such pressure.

While in these diagrams the height $a\,b$

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and the length *c d* are greatly out of proportion, the figure will nevertheless serve as an illustration of how the storm wave is produced. The height at which the water may thus be raised will evidently depend on its mass or depth. Thus, far out in the ocean, where the depth is considerable, the height attained may possibly not exceed two or three feet and hence not be perceptible on account of the enormous sea caused by the wind, but when a storm advances toward a coast and the depth decreases the height of this wave will increase in direct proportion. It was this storm wave that flooded Galveston and put on the finishing touches of destruction. Had the city been protected by a breakwater or sea-wall of sufficient height and strength this greatest catastrophe of recent years would have been averted, or at least diminished. Galveston had been warned several times before, by previous storms, and the city had been flooded, but humanity seldom accepts the lesson of experience.

A few particulars about the progressive motion of the Galveston hurricane may perhaps prove a fitting conclusion to this article. The storm originated, about August 30, southeast of Puerto Rico. For some days previous to that date a decreasing pressure and abnormal movement of the cirrus clouds indicated that a storm of cyclonic nature was brewing. On the morning of September 1, its center was south of the Island of Santo Domingo; it moved slowly in a northwesterly direction, and by the morning of September 4 it was south of the middle Cuban coast. It reached Havana on the 5th without very destructive winds. On the morning of the 6th the center was slightly north of Key West, and by the evening of the same day it was near the Florida coast, a short distance south of Tampa. Then came a sharp turn to the west, the hurricane gradually gaining in strength, and on the morning of September 7 it was in the Gulf of Mexico, apparently about 200 miles south of the Mississippi coast. The coast of Texas and the city of Galveston was reached by the storm during the afternoon of September 8. From there it turned in a northerly direction, passing through the Indian Territory, Kansas, and the extreme easterly portion of Nebraska. On September 11, it reached the region of the Great Lakes and caused considerable damage along the shores of Lake Erie, especially at Buffalo, where several buildings under erection for the Pan-American Exposition were damaged. On the morning of September 12 it left the coast of Nova Scotia and proceeded seaward in an easterly direction, apparently following the transatlantic steamship route. It had by this time lost its destructive character and was principally engaged in causing general rains in its vicinity. On the morning and throughout the day of September 25, its effects were felt in England and in the north of France by torrents of rains and high winds, and on September 27th it made its entry into the North German States and finally dispersed north of the Baltic. In case the European dispatches are confirmed by observers of the transatlantic fleet they will show that this storm was the greatest on record, it having traveled a distance of more than 7,000 nautical miles.

SCENE ON THE TEXAS COAST NEAR GALVESTON THE DAY AFTER THE GREAT HURRICANE HAD SWEPT IT
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CABLE SPLICING

THE PROCESS FOR RUBBER-COVERED CABLES AND FOR LEAD-COVERED CABLES WITH PAPER INSULATION—CUTTING THE SHEATH—BOILING OUT—SUBMARINE CABLES

THE term splice, as used in the electrical industries, is defined as "the joining of two electric conductors in such a manner as to make a continuous electric circuit." When the term is applied to cables, however, it refers not only to the joining of the conductors contained therein, but also to the joining of the adjacent ends of the cable coverings in such a manner as to give the same protection for the conductors at the point of splicing as is afforded throughout their length. As the conductors of electric cables, and particularly those used in telephony, must be protected in the most careful manner, both against mechanical injury and against the action of the weather, it is very essential when a splice is made that the conductors at this point

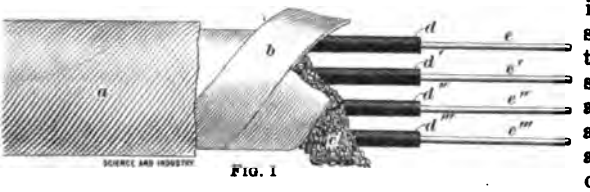

FIG. 1

should be rendered as safe as at any other point along the line. Indeed, it might be said that, for reasons that will appear later, better protection should be afforded here than at any other point along the line. Owing to this fact, it may be said that the distinctive feature of cable splicing is the protection given to the conductors at the point of their junction.

It will be assumed, in this article, that the reader is familiar with the method of manufacture of cables, and consequently this point will not be touched on. Regarded from the standpoint of the cable splicer, telephone cables are divided into three classes: (1) those having the conductors protected by cotton braiding; (2) those having the conductors protected by a lead sheath; (3) those having this lead sheath, in turn, protected by iron wire wound helically about its length. The cables of the first class are used for overhead, or aerial, lines exclusively; those of the second class for both aerial and subway lines; and those of the third class for submarine work exclusively.

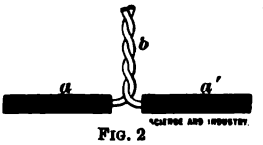

FIG. 2

In splicing rubber cables, the adjacent ends are brought together and the braid covering, tape covering, and jute serving are peeled back to a point 4 inches distant from the end, and the wires with their rubber

FIG. 3

insulation thus exposed. The insulation is then cleaned off each wire to a point as near the beginning of the braid covering as possible, care being taken to clean the wire in such a manner as to leave the surface bright and shiny. In Fig. 1 will be seen a rubber-insulated cable end prepared for splicing. The braid is shown at *a*, the tape covering at *b*, and the jute serving at *c*. The ends of the wires are shown exposed at *e*, *e'*, *e''*, *e'''*, and the rubber insulation is shown at *d*, *d'*, *d''*, *d'''*. The ends of both cables having been thus prepared, the end of one conductor in one cable is joined to the end of one wire in the next, this process being continued until all the wires have been connected.

The joining of the ends of the wires is the splicing, and it is done in two ways: either the ends are brought together simply twisted, as shown at *b*, Fig. 2, or they are treated as shown in Fig. 3, in which the end of the first wire is wrapped around the second wire

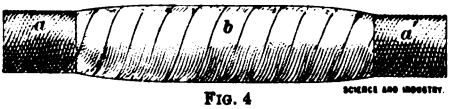

FIG. 4

and the end of the second wire is, in turn, wrapped around the first but in the reverse direction. The first splice, or that shown in Fig. 2, is called a "common splice"; the second, shown in Fig. 3, is called a "Western Union splice." In splicing lead-covered cables, the former is always used, but in splicing braid-covered cables, the Western Union splice only is permissible. On the whole, the Western Union splice is the better,

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as it has a much greater tensile strength.

The wires in the rubber cables having been spliced, each joint is wrapped with a piece of approved waterproof tape of sufficient length to make three layers. After

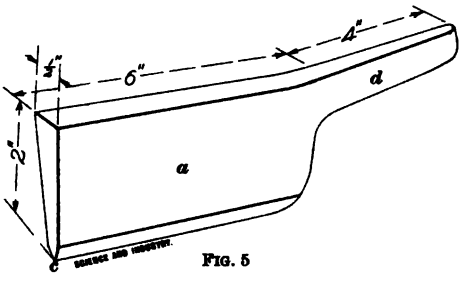

FIG. 5

this has been done, the wires at the splice are wrapped with several layers of heavy tarred tape, of sufficient length to render this section of the same thickness as the cable. This wrapping should cover the braid on the cable for a distance of three inches from the points where it is cut. This is shown in Fig. 4, where a and a' represent the ends of the two cables that have just been spliced, and b represents the heavy tarred tape wrapping about the point of splicing. In the last two years there has been a tendency shown to solder the joints in the wires, but it has not become the universal practice.

The work of splicing lead-covered cables is more elaborate than that already described, on account of the fact that the lead sheath must be made continuous, and the conductors must be protected from the weather as securely at this point as in

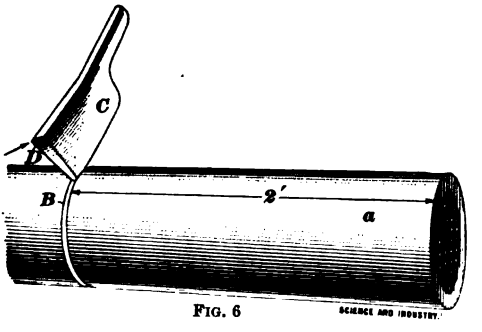

FIG. 6

the cable itself. The work therefore divides itself into two parts: that of properly joining the conductors, and that of properly joining the adjacent ends of the lead sheath. Whatever moisture may have entered the cable ends between the completion of the first process and the beginning of the second must be expelled, and the work necessary to accomplish this object is called "boiling out."

The two cables on which the splice is to be made are drawn together until their ends overlap from 2 to 4 feet, according to the nature of the conditions. When splices have to be made in manholes where the cables are made to either bend around the side of the hole or to lie loosely on its floor, the cable ends are made to overlap as much as 4 feet, in order to give sufficient slack when the splicing is done. When cables are suspended from poles, however, no slack is needed, as the sag is not increased at the point of splicing, so that the ends are made to overlap only enough to allow of the performance of the work in the proper manner. But in any case the work of splicing is performed as follows:

The lead sheath is cut away from both cable ends to the distance of 1 foot, and the conductors and their paper insulation exposed. It is very important, in order that the conductors may not be injured, that the sheath should be removed in the proper manner. The tool used for this work is called a chipping knife, and

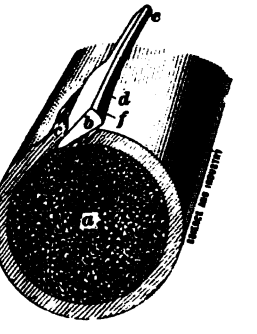

FIG. 7

is shown in Fig. 5. It will be seen to be a heavy broad-backed blade a having a stout edge c and a handle d. It is made of tool steel. In Figs. 6 and 7 is shown the proper method of removing the lead sheath. In Fig. 6, at a point about 2 feet from the cable end, a circular groove is cut at B in the sheath a. In doing this the chipping knife C is held in the position shown, while blows are struck with a hammer on the head D, in the direction indicated by the arrow, so as to give it a tangential motion. In this way the sheath is cut, without the knife being allowed to cut down into the conductors. This groove having been cut, a longitudinal incision is made from it to the cable end. The method of holding the knife for this work is shown in Fig. 7, where b represents the end of the knife, d its back, and e

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its handle, all foreshortened. As before, the blows are struck at the point *f*, and the knife is thus given a backward and tangential motion combined, which rips off the

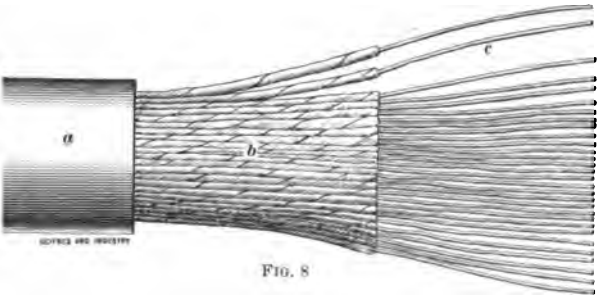

FIG. 8

sheath, as shown at *c*, without the possibility of injuring the conductors.

The sheath having been thus removed, the conductors are prepared for splicing in the following manner: The conductors are spread, and the paper insulation removed from each to a point about 4 inches from the end. Over each conductor is then slipped a cotton sleeve about 6 inches long and of sufficient diameter to slip easily over the insulation. In Fig. 8 are shown the conductors spread and

FIG. 9

cleaned. At *a* is seen the end of the sheath, at *b* the exposed paper insulating covering of the conductors, and at *c* the conductors cleaned of the insulation preparatory to splicing. In Fig. 9 is shown one conductor over which has been slipped the woven cotton sleeve *b*. At *a*, *a* will be seen the insulated conductor, and at *c* the same conductor cleaned of insulation. In Fig. 10 will be seen one conductor spliced to a corresponding one in the next cable. As before, *a*, *a* is the insulated conductor of the one cable, and *a'* that of the other. At *c*

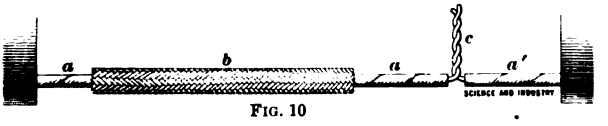

FIG. 10

will be seen their naked ends joined by a "common splice." The splice having been thus made, the joined ends are bent flat, as shown at *c*, Fig. 11, and the sleeve *b* is slipped over the joint, as shown in Fig. 12. This process is continued until every conductor in one cable has been joined to a corresponding one in the next.

The actual work of splicing having been thus finished, the moisture that has accumulated on the conductors and paper insulation during the time of their exposure must be removed. This is done in the following manner: Melted paraffin is poured on the conductors and allowed to cool. The action of the paraffin is to drive out, by its heat, whatever moisture may be contained in the paper and saturate its pores so as to make it impervious to further dampness. At the completion of this part of the work, the splice takes on the appearance shown in Fig. 13,

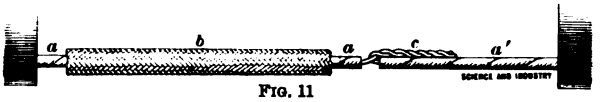

FIG. 11

where the sheaths of the two cables are shown at *a* and *a'*, the insulated conductors at *b* and *b'*, and the protecting sleeve at *c*.

It will be well to review at this point the work that has already been accomplished. First of all, the lead sheaths have been cut away, to admit of the proper handling of the conductors; the conductors have been properly joined; and the accumulated moisture, consequent upon the removal of the lead covering, has been boiled out. There yet remains the final

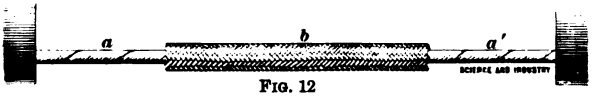

FIG. 12

work of joining together the parted ends of the lead sheath so as to give the conductors at the splice the same protection provided for them throughout the cable length, and also to preserve as nearly intact as possible the tensile strength of the cable as a whole. This is accomplished by making what the plumber calls a "wiped joint." It is done in the following manner: Before the work of joining the conductors is started, a lead "sleeve" of somewhat larger diameter than that of the cable is slipped over one of the sheaths. This sleeve must be about 8 inches longer

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than the distance between the ends of the two sheaths after the splice has been made. Upon the completion of the work already described, this sleeve is moved up so as to cover the exposed conductors, with its two

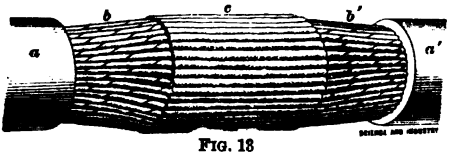

FIG. 13

ends overlapping by 4 inches those of the two sheaths.

At *d*, in Fig. 14, is shown this sleeve before being moved to its proper place. The two sheaths will be seen at *a* and *a'*, the conductors at *b* and *b'*, and the cotton sleeves at *c*. The surface of the sheath is now scraped bright and clean, and the lead sleeve is moved into place. This being done, its ends are hammered down so as

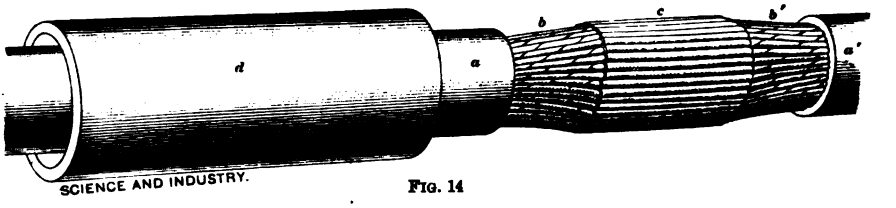

FIG. 14

to make a binding fit upon the sheath. This is shown in Fig. 15. It will be seen that the ends of the lead sleeve are hammered down so as to fit tightly over the sheath. The cable splicer is provided with a pot in which is melted lead. Underneath this pot is placed a charcoal or gasoline furnace. When the lead has been melted, it is poured gently over the junction between the sleeve and the cable sheath with one hand, and is patted and smoothed into shape by the other, which is protected by a mat made for the purpose. The molten lead thus poured on forms a perfectly air-tight joint and one that has very nearly the same tensile strength as the cable sheath itself. This last performance completes the work of splicing.

Submarine cables are seldom spliced. It is well to avoid this work wherever possible. There are times, however, when it must be done, and then the utmost care must be taken to secure perfect insulation at the splice and also security from mechanical injury. The conductors of submarine telephone cables are usually made of three strands of No. 22 B. & S. gauge wire, to give sufficient conductivity and yet insure the requisite flexibility. The insulation is usually rubber. In making a submarine splice, the armor wires are bent back and unwound for a distance of about two feet from the end of the cable, to expose the lead sheath. As in the case of the lead cable, the sheaths are removed to give access to the conductors. The wires are joined by the common splice and soldered. The joints are protected with several layers of tape, and the conductors are bound up with two or three layers of tape. A wiped joint is then made as already described, and the work is completed with the exception of splicing the armor wires.

Armor wires are generally made of galvanized steel .22 inch in diameter. They are wound on helically and held in place by a layer of tarred oakum. In splicing, steel sleeves two inches long and of sufficient diameter to fit tightly over the armor wires are slipped over those of one cable. The

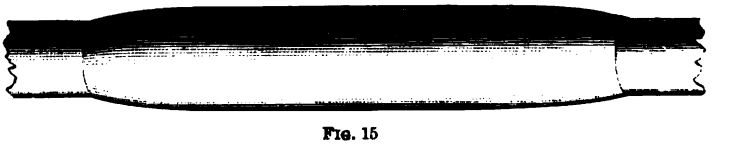

FIG. 15

armor wires are then cut to such a length as to make those on one cable butt against those on the other when they are lying in their proper positions on the sheath. The joints are soldered.

The method of testing out conductors before and after splicing will form the subject of another paper.

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RIVETED JOINTS

John A. Greening

EFFICIENCY OF JOINTS—LIMITATIONS—PRACTICAL CONSIDERATIONS—RULES FOR PROPORTIONING JOINTS—THE ACTUAL DESIGN OF JOINTS

JUDGING from the numerous requests received from readers, the subject of calculating the strength of joints for steam boilers and the method of designing the joints are not generally understood. It will be found, when the literature bearing upon this subject is examined with a view of profiting by a study of it, that in the great majority of standard textbooks the subject is treated from the purely theoretical standpoint, and on applying the theoretical formulas deduced results are often obtained that, viewed in the light of experience, appear rather strange, to say the least. None of the textbooks that the writer has ever seen up to this time shows the actual method of procedure of designing a joint, by the exercise of judgment, for the maximum efficiency attainable with the style of joint chosen, as has been attempted in this article. Now, as far as purely theoretical rules for designing joints go, they serve a useful purpose; strange results obtained by their use must not be charged against the *rules*, but rather against the user of them, since, in applying these rules, at least one dimension has to be assumed. The result depends entirely on the correctness of the assumption that has to be made; if it happens to be within a certain range, the joint will have a high efficiency and be properly proportioned. If the dimension was assumed outside of that range, the result may be such as to make the joint worthless, viewed from the standpoint of the boilermaker and engineer. For this reason it is necessary for the designer to know the limits that practical experience has shown must not be exceeded. These limits are not very sharply defined, as will appear later on, when the rules given by different authorities are compared. They are definite enough, however, to prevent a ridiculous design, if the design is checked by them.

In order to design a joint, it is necessary for the reader to understand the different ways in which riveted joints may fail, what is meant by efficiency of a joint, how the efficiency may be calculated, and how the strengths of the component parts of a joint are calculated and compared with each other.

It is the aim of the designer, when designing a rivet joint, to distribute and proportion the rivets in such a manner that the strength of the joint shall be as nearly equal to the strength of the solid plate as is practicable. The ratio between the strength of the plate and the strength of the joint is called the *efficiency of the joint*, and is commonly expressed as a percentage of the strength of the solid plate. It is customary, when calculating the efficiency of a joint, to consider the plate to be divided into a number of equal strips, at a right angle to the joint. Conceiving the riveting to be divided into equal groups, the width of the equal strips is to be such as to enclose one group of rivets.

The lines $A\,B$ and $C\,D$ in Fig. 1 indicate the width of the strip containing a group of rivets. For single-riveted, double zigzag-riveted, and double chain-riveted lap joints and butt joints, and triple-riveted lap joints the width of the strip will be equal to the pitch of the rivets. In a triple-riveted butt joint with two cover plates and every alternate rivet in the outer row left out, as shown at (h), Fig. 1, the width of the strip is to be taken as equal to the pitch of the rivets in the outside row.

In order to determine the efficiency of the joint, its resistance must be computed for each of the different ways in which it may fail. Then, if 100 times the lowest resistance of the several parts of the joint is divided by the resistance of the solid plate, the efficiency of the joint will be obtained, expressed in per cent.

A riveted joint may fail in one of several ways: (1) The plate may break along the rivet holes, as shown at a, Fig. 2; this shows the rivets to be stronger than the plate. (2) The rivets may shear off, as shown at b; this indicates that the plate is stronger than the rivet. (3) The plate in front of the rivet may shear out, as shown at c. (4) The plate may crush in front of the rivet. Experiments show that when the different kinds of joints fail by breakage of the plates, this breakage occurs most often in the manner shown in Fig. 1—that is, along the line $a\,a$ through the rivet holes. It is evident

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that the rivet hole has the effect of reducing the area of the section of the strip by an amount equal to its diameter multiplied by the thickness of the plate. The difference between the original cross-sectional area of the strip and the product obtained by multiplying the diameter of the rivet hole by the thickness of the plate is the *net area*, or the *net section*, of the strip.

Double zigzag-riveted joints have been known to fail along lines drawn from the center of one rivet in one row to the center of the next rivet in the adjacent row. With the rivet spacing ordinarily employed, the liability of the joint to fail in this manner is small; and, as it is a rather difficult matter to calculate the resistance to failure along these diagonal lines, it is customary to disregard it and calculate the resistance of zigzag-riveted joints, on the assumption that failure will take place along the line $a\,a$, Fig. 1.

Let R = the resistance of the solid strip to tensile stress;
R_n = the resistance of the net section of the strip to tensile stress;
R_s = total resistance of the rivets in the strip to shearing stress;
t = thickness of strip, in inches;
w = width of strip;
N = number of rivets resisting shear;
d = diameter of rivet hole;
p = pitch of rivets;
T = ultimate tensile strength per square inch of section;
S = ultimate shearing strength per square inch of section.

The resistance of the solid strip to tensile stress is given by the following rule:

RULE 1.—*Multiply the ultimate tensile strength of the material by the thickness of the plate and the width of the strip;*

or, $$R = Ttw.$$

The resistance of the net section of the plate to a tensile stress is given by the following rule:

RULE 2.—*From the width of the strip subtract the diameter of the rivet hole. Multiply the remainder by the thickness of the plate and its ultimate tensile strength;*

or, $$R_n = (w - d)\,t\,T.$$

When the joint is subjected to tensile stress, there will be a tendency to shear the rivets. In lap and butt joints with single cover plates, the rivets are in single shear; in butt joints with double cover plates they are in double shear. In triple-riveted butt joints designed as shown at (h), Fig. 1, where the inside cover plate is wider than the one on the outside, the two inside rows of rivets are in double shear and the outside row in single shear.

The reader is cautioned against considering a butt joint like that shown at (e), Fig. 1, as a double-riveted joint. The butt joints in Fig. 1 are, respectively: (e), single riveted; (f), double zigzag riveted; (g), double chain riveted; and (h), triple riveted. That the joint shown at (e) is single riveted follows from the fact that the separation of one plate from the other is opposed by only one row of rivets.

The shearing resistance of rivets in double shear is not twice their resistance in single shear, as is often assumed. Experiments on steel and iron rivets at the Watertown Arsenal have shown that their resistance in double shear averages 1.85 times their resistance in single shear.

The shearing resistance of the rivets in the strip considered may be calculated as follows:

RULE 3.—*Multiply the area of the rivet hole by the number of rivets resisting the shear in the strip considered. Multiply this product by the ultimate shearing strength of the rivet material. When the rivets are in double shear, multiply again by 1.85;*

or, $R_s = d^2 \times .7854\ NS$ for single shear,
and $R_s = d^2 \times .7854\ NS \times 1.85$ for double shear.

The attention of the reader is called to the fact that *the area of the rivet hole* is used in calculating the shearing resistance of the rivets. It is the usual practice to make the rivet hole $\frac{1}{8}$ inch larger than the rivet. When the rivet is driven it fills the hole, and its new area, which is equal to the area of the hole, in conjunction with the shearing strength of the material, determines the shearing resistance.

Considering the case of failure by shearing out and crushing in front of the rivet, experiments have shown that, with the rivet spacing and proportions usually employed, there is no danger of the joint failing in this manner if the distance from the center of the rivet to the edge of the plate is made one and a half times the diameter of the rivet hole.

The efficiency of a joint may be investigated by applying rules 1, 2, and 3. First of all, determine the resistance of the solid plate, then the resistance of the net section to tensile stress, and finally the shearing resistance of the rivets; then find the efficiency as explained at the beginning of the article.

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EXAMPLE.—In a single-riveted lap joint, as shown at (*a*), Fig. 1, the pitch of the rivets is 2 inches; the rivet holes are $\frac{7}{8}$ inch in diameter; the plate is $\frac{3}{8}$ inch thick and has an ultimate tensile strength of 55,000 pounds per square inch of section. Taking the ultimate shearing strength of the rivet material at 38,000 pounds per square inch of section, what is the efficiency of the joint?

SOLUTION.—According to the statement previously made, a strip 2 inches wide is to be considered. By rule 1, its resistance to a tensile stress is $55{,}000 \times 2 \times \frac{3}{8} = 41{,}250$ lb. By rule 2, the resistance of the net section to a tensile stress is $(2 - \frac{7}{8}) \times 55{,}000 \times \frac{3}{8} = 23{,}203$ lb.

As there is one rivet in the strip in single shear, its shearing resistance, by rule 3, is $(\frac{7}{8})^2 \times .7854 \times 1 \times 38{,}000 = 22{,}850$ lb.

Comparing the two resistances, it is seen that the joint will fail by shearing the rivet. The efficiency of the joint is $\frac{22{,}850}{41{,}250} \times 100 = 55.4\%$, nearly. Ans.

EXAMPLE.—In a triple-riveted lap joint, such as shown at (*d*), Fig. 1, the pitch of the rivets is $3\frac{1}{4}$ inches; the rivet holes are $1\frac{3}{16}$ inch in diameter; the plate is $\frac{3}{8}$ inch thick, and has an ultimate tensile strength of 60,000 pounds per square inch of section; the ultimate shearing strength of the rivet iron is 38,000 pounds per square inch of section. Find the efficiency of the joint.

SOLUTION.—According to the statement previously made, a strip $3\frac{1}{4}$ inches wide is to be considered. The resistance of the solid strip to a tensile stress, by rule 1, is $60{,}000 \times 3\frac{1}{4} \times \frac{3}{8} = 73{,}125$ lb. By rule 2, the resistance of the net section to a tensile stress is $(3\frac{1}{4} - 1\frac{3}{16}) \times 60{,}000 \times \frac{3}{8} = 54{,}843.7$ lb. There being three rivets in single shear in the strip to resist the shearing stress, the shearing resistance, by rule 3, is $(1\frac{3}{16})^2 \times .7854 \times 3 \times 38{,}000 = 59{,}107.5$ lb.

The calculations show that the net section of the plate is weakest. The efficiency of the joint is $\frac{54{,}843.7}{73{,}125} \times 100 = 75\%$. Ans.

EXAMPLE.—Find the efficiency of a triple-riveted butt joint with two cover plates, having every alternate rivet in the outer row left out. The outer row of rivets is in single shear and the inner rows are in double shear [see (*h*), Fig. 1]; the pitch of the rivets in the inner rows is $3\frac{3}{4}$ inches, in the outer row $7\frac{1}{2}$ inches; the rivet holes are 1 inch in diameter; the plate is $\frac{1}{2}$ inch thick, and has an ultimate tensile strength of 55,000 pounds; the shearing strength of the iron rivets is 38,000 pounds per square inch of section.

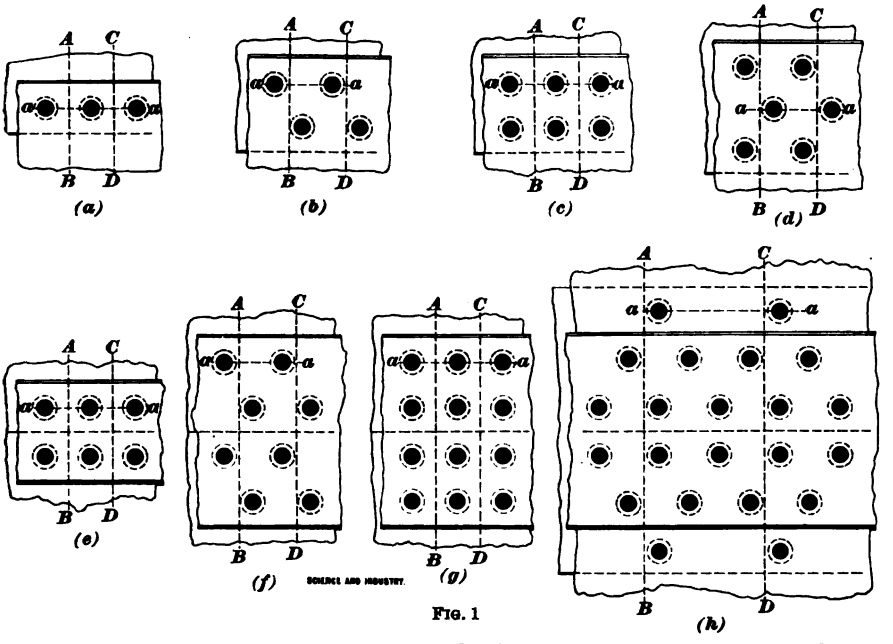

FIG. 1

SOLUTION.—According to the previous statement, a strip $7\frac{1}{2}$ inches wide is to be considered. The resistance of this strip to tensile stress, by rule 1, is $55{,}000 \times \frac{1}{2} \times 7\frac{1}{2} = 206{,}250$ lb. By rule 2, the resistance of

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the net section of the plate is $(7\frac{1}{2} - 1) \times 55{,}000 \times \frac{1}{2} = 178{,}750$ lb.

In the strip we are considering, there are four rivets in double shear and one rivet in single shear. Then, the total shearing resistance is the sum of the resistances of the five rivets. By rule 3, the resistance of the rivet in single shear is $1^2 \times .7854 \times 1 \times 38{,}000 = 29{,}845.2$ lb. By the same rule, the resistance of the four rivets in double shear is $1^2 \times .7854 \times 4 \times 38{,}000 \times 1.85 = 220{,}854.5$ lb., nearly. Hence, the total resistance to the shearing stress is $220{,}854.5 + 29{,}845.2 = 250{,}699.7$ lb. The calculations show the net section of the plate to be weakest. The efficiency of the joint is then $\frac{178{,}750}{206{,}250} \times 100 = 86.66\%$. Ans.

Although it may at first appear possible to design a riveted joint to give the maximum strength for a certain plate and quality of rivets, merely by an application of the principles of strength of materials, a closer investigation of the problem will prove that, owing to the number of conditions imposed, it is impossible to formulate a theoretical rule for the solution of the general problem. Either the diameter of the rivets or the pitch must be assumed and a joint designed that will fulfil the conditions of equality between strength of rivets and strength of plate, but it is impossible to derive a general rule by means of which the diameter or the pitch of rivets that will secure the *maximum strength of joint* for a given thickness and quality of plate can be directly calculated. On account of these limitations the design of a joint that will give the maximum efficiency is a tentative problem. Either the diameter or the pitch may be assumed and the efficiency of the corresponding joint may be calculated. Another size or pitch of rivet may then be chosen and the efficiency of the corresponding joint calculated. The second efficiency compared with the first will show in which direction a change in dimensions will be likely to give the best results. A few trials of this kind will reveal the dimensions required to give the most satisfactory results.

Practical considerations limit the design to a narrow range of values of diameters and pitch. Commercial sizes of rivets and thickness of plates, the greatest pitch with which a steam-tight joint can be secured, and the smallest pitch that will permit of the formation of rivet heads must all be considered. It is also customary to make the pitch some even number of inches, or, when fractions are used, to restrict them to such numbers as halves, quarters, or eighths of an inch.

In consequence of the limitations within which theory can be applied and the practical features of the work, many designs of riveted joints are based on a series of simple empirical rules and on tables of dimensions that have been found by experience to give satisfactory results.

Regarding the pitch of rivets which must not be exceeded if the joint is to be steam-tight when under pressure, competent authorities differ somewhat. The difference of opinion accounts for much of the difference in results that will be obtained from the formulas proposed by different authorities on boiler design.

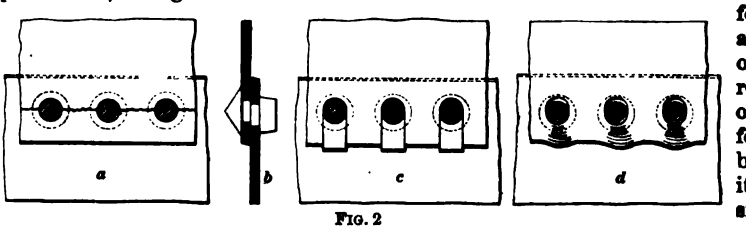

FIG. 2

The meaning of the symbols used in the following practical rules and formulas is defined below.

p = pitch of rivets;
n = number of rows of rivets;
p_m = maximum pitch allowable;
p_d = diagonal pitch;
d = diameter of rivet hole;
d' = diameter of rivet;
t = thickness of plate;
v = distance between adjacent rows of rivets;
e = distance from center of rivet to edge of plate;
l = lap.

The Board of Supervising Inspectors of Steam Vessels, in their rules and regulations governing the construction of steam boilers for marine purposes, prescribe the following rules for single- and double-riveted lap joints:

$d' = t + \frac{1}{8}''$ for iron plates and iron rivets, single-riveted lap joint; (a)

$d' = t + \frac{1}{16}''$ for iron plates and iron rivets, double-riveted lap joint; (b)

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$d' = t + \frac{7}{16}''$ for steel plates and steel rivets, single-riveted lap joint; (c)

$d' = t + \frac{5}{8}''$ for steel plates and steel rivets, double-riveted lap joint; (d)

$p = \frac{.7854\, d'^2 n}{t} + d'$ for iron plates and iron rivets; (e)

$p = \frac{.64515\, d'^2 n}{t} + d'$ for steel plates and steel rivets; (f)

$p_m = 1.31\, t + 1\frac{5}{8}''$ for single-riveted lap joints; (g)

$p_m = 2.62 + 1\frac{5}{8}''$ for double-riveted lap joints; (h)

$p_d = \frac{6\, p + 4\, d'}{10}$ for double zigzag-riveted lap joints; (i)

$v = \frac{4\, d' + 1}{2}$ for double chain-riveted lap joints; (k)

$v = \frac{\sqrt{(11\, p + 4\, d')(p + 4\, d')}}{10}$ for double zigzag-riveted lap joints; (l)

$e = 1.5\, d'$. (m)

The American Boiler Manufacturers' Association, in their "Uniform American Boiler Specifications," adopted October, 1898, in section 10, specify: Approximately make rivet holes double the thickness of thinnest plate [$d = 2\, t$, approximately; (n)]. Make pitch three times the diameter of the rivet hole [$p = 3\, d$; (o)]. Make the distance between the center lines of rows of staggered rivets equal to one-half the pitch [$v = .5\, p$; (p)]. Make lap for single riveting equal to the pitch [$l = p$; (q)]. Make lap for double riveting one and one-third times the pitch [$l = 1\frac{1}{3}\, p$; (r)]. For each additional row of rivets in excess of double riveting, add one-half the pitch to the lap [$l = 1\frac{1}{3}\, p$, for triple riveting; (s)]. [$l = 2\frac{1}{3}\, p$ for quadruple riveting; (t)]. Exact dimensions of the joint are to be determined by making the resistance to shear of rivets at least 10 per cent. greater than the resistance to tensile stress of the net section of the plate.

For double-riveted butt joints with two cover plates, the English Board of Trade prescribes that the pitch of the rivets must not exceed that given by the following formula:

$$p_m = 3.5\, t + 1\tfrac{5}{8}''. \quad (u)$$

For triple-riveted butt joints with two cover plates, the same authority gives

$$p_m = 4.63\, t + 1\tfrac{5}{8}''. \quad (v)$$

For finding the diagonal pitch for butt joints with one or two cover plates, formula (i) may be used.

When one cover plate is used, make its thickness not less than

$$1\tfrac{1}{8}\, t. \quad (w)$$

For two cover plates, the thickness of each should not be less than

$$\tfrac{5}{8}\, t. \quad (x)$$

The Hartford Steam Boiler Inspection and Insurance Co. have designed and recommend the joints given in the accompanying table, the designs being for steel plate and iron rivets. With the values of the ultimate tensile and shearing strengths given, the efficiency of these joints is found in the last column.

The efficiency of a riveted joint depends upon several interdependent factors: the diameter of the rivet when driven, the pitch of the rivets, the ultimate tensile and shearing strength of the material, and the disposition of the rivets. A change in either one or more of these factors will alter the efficiency of the joint.

For illustration, take a single-riveted lap joint for a plate $\frac{7}{16}$ inch thick, having a diameter of rivet hole of $\frac{11}{16}$ inch and a pitch of $2\frac{1}{8}$ inches. The plate has a tensile strength of 60,000 pounds, and the rivet a shearing strength of 38,000 pounds. This joint will have an efficiency of 49.5%, nearly.

All other data remaining the same, with the exception of the tensile strength of the plate, which we will now take at 55,000 pounds, the same joint will have an efficiency of 53.9%, nearly.

The reader is here cautioned against the error of assuming that a low tensile strength of the plate will be conducive to a stronger joint. The calculations just given are merely intended to show that a change in one or more of the factors entering into the problem will work a corresponding change in the ratio between the strength of the joint and the strength of the solid plate.

The general method of procedure outlined below may be followed in designing a joint.

1. Fix on the maximum permissible pitch for the type of joint and the thickness of plates to be used.

2. Choose a standard diameter of rivet that agrees as closely to practice for this style of joint as may be determined by the data available; in the absence of data use judgment.

3. Calculate the shearing strength of the rivet or rivets in the strip whose width is determined by the pitch, and the width of a strip of the plate that will have a tensile strength equal to the shearing strength of the rivet or rivets.

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Position of Joint.	t	t'	t''	d'	d	e	e'	v''	v	v'	p	p'	Ultimate Tensile Strength.	Ultimate Shearing Strength.	Efficiency.
Girth seam, when longitudinal seams are double riveted.	⅜			⅝	⅞	1¼	1⅛			2⅛	2⅛		60,000	38,000	74%
	½			⅝	⅞	1¼	1⅛			2⅛	2⅛		60,000	38,000	72%
	⅝			⅝	⅞	1¼	1⅛			2⅛	2⅛		60,000	38,000	71%
	¾			⅝	⅞	1¼	1⅛			2⅛	2⅛		60,000	38,000	70%
	⅞			1	1⅛	1⅜	1⅛			2⅛	2⅛		60,000	38,000	70%
Girth seam, when longitudinal seams are triple riveted.	⅜			⅝	⅞	1¼	1⅛			2⅛	2⅛		60,000	38,000	74%
	½			⅝	⅞	1¼	1⅛			2⅛	2⅛		60,000	38,000	72%
	⅝			⅝	⅞	1¼	1⅛			2⅛	2⅛		60,000	38,000	71%
	¾			⅝	⅞	1¼	1⅛			2⅛	2⅛		60,000	38,000	70%
	⅞			1	1⅛	1⅜	1⅛			2⅛	2⅛		60,000	38,000	70%
Longitudinal seam.	⅜			⅝	⅞	1¼	1⅛		1¼	2⅛	2⅛		60,000	38,000	77%
	½			⅝	⅞	1¼	1⅛		1¼	2⅛	2⅛		60,000	38,000	76%
	⅝			⅝	⅞	1¼	1⅛		1¼	2⅛	2⅛		60,000	38,000	75%
	¾			⅝	⅞	1¼	1⅛		1¼	2⅛	2⅛		60,000	38,000	75%
	⅞			1	1⅛	1⅜	1⅛		1¼	2⅛	2⅛		60,000	38,000	75%
Longitudinal seam.	⅜			⅝	⅞	1¼	1⅛		1¼	2⅛	2⅛		60,000	38,000	77%
	½			⅝	⅞	1¼	1⅛		1¼	2⅛	2⅛		60,000	38,000	76%
	⅝			⅝	⅞	1¼	1⅛		1¼	2⅛	2⅛		60,000	38,000	75%
	¾			⅝	⅞	1¼	1⅛		1¼	2⅛	2⅛		60,000	38,000	75%
	⅞			1	1⅛	1⅜	1⅛		1¼	2⅛	2⅛		60,000	38,000	75%
Longitudinal seam.	⅜	⅜	⅜	⅝	⅞	1¼	1⅛	⅞	1⅜	2⅛	2⅛	2⅛	55,000	38,000	88%
	½	½	½	⅝	⅞	1¼	1⅛	⅞	1⅜	2⅛	2⅛	2⅛	55,000	38,000	87.5%
	⅝	⅝	⅝	⅝	⅞	1¼	1⅛	⅞	1⅜	2⅛	2⅛	2⅛	55,000	38,000	86%
	¾	¾	¾	⅝	⅞	1¼	1⅛	⅞	1⅜	2⅛	2⅛	2⅛	55,000	38,000	86.6%
	⅞	⅞	⅞	1	1⅛	1⅜	1⅛	1	1⅝	2⅛	2⅛	2⅛	55,000	38,000	86.4%
	1	1	1	1	1⅛	1⅜	1⅛	1	1⅝	2⅛	2⅛	2⅛	55,000	38,000	84%

Joint.

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4. Add the width of this strip to the diameter of the rivet hole, and thus obtain the pitch of the rivets required to make the tensile strength of the plate equal to the shearing strength of the assumed rivets.

5. Compare the pitch thus obtained with the assumed maximum permissible pitch; if the calculated pitch is greater than the permissible pitch, calculate again, using a smaller rivet; if it is less, try a larger rivet.

6. In this way determine the two sizes of rivets that will give pitches nearest to the maximum permissible pitch, one greater and one less.

7. Calculate the efficiency of the joint whose pitch of rivets is next lower than the maximum permissible pitch.

8. Calculate the efficiency of a joint having the maximum permissible pitch, using the larger of the two rivets found in 6.

9. The one of these two joints having the higher efficiency will be the joint having the highest efficiency obtainable with commercial sizes of rivets, under the assumed conditions.

This method of procedure may be considerably varied to suit special conditions. In many cases a simple inspection will enable an experienced designer to determine most of the features of the joint without the necessity of making all of the calculations involved in the above outline. For the beginner, however, it is best to check each step by careful calculation.

ILLUSTRATIVE EXAMPLE.—Design a double zigzag-riveted butt joint with two cover plates, the shell plate being steel $\frac{3}{4}$-inch thick and having a tensile strength of 60,000 pounds per square inch of section. The rivets are of steel having a shearing strength of 45,000 pounds per square inch of section.

Referring to the rules for proportions of joints, we find that the only rule for fixing the limit of pitch for the kind of joint under consideration is that prescribed by the English Board of Trade (see formula u); in accordance with this formula, the maximum permissible pitch for our joint is $p_m = 3.5 \times \frac{3}{4} + 1\frac{5}{8} = 4.25$ inches.

There are no rules for the diameter of rivets for a double-riveted butt joint, but by referring to the proportions recommended by the Hartford Steam Boiler Inspection and Insurance Co., we find that a triple-riveted butt joint in a $\frac{5}{8}$-inch plate is provided with 1-inch rivets having a shearing strength of 38,000 pounds per square inch. Although these conditions differ somewhat from the ones we are considering, they may be taken as an indication of the most probable size we will need; we will, therefore, use a 1-inch rivet for our first *trial size*. For this size the shearing strength of the two rivets included within a strip of plate having a width corresponding to the pitch is, by rule 3, $R_s = (1\frac{1}{16})^2 \times .7854 \times 2 \times 46{,}000 \times 1.85 = 150{,}900$ pounds. It will be observed that in this calculation the diameter of the rivet hole is used, which is $\frac{1}{16}$ inch larger than the rivet.

We will now calculate the pitch that would be required to secure the same strength for the plate. The tensile strength of a strip of the plate 1 inch in width is, by rule 1, $1 \times \frac{3}{4} \times 60{,}000 = 45{,}000$ pounds; the net width of plate required to secure a strength equal to the shearing strength of the rivets is, therefore, $150{,}900 \div 45{,}000 = 3.353 = 3\frac{3}{8}$ inches, nearly. Since the diameter of the rivet hole is $1\frac{1}{16}$ inches, the pitch required will be $3\frac{3}{8} + 1\frac{1}{16} = 4\frac{7}{16}$ inches, which is greater than the permissible maximum pitch we have assumed for our joint. We will now try the next smaller size of rivet, $1\frac{3}{16}$ inch, making the size of the rivet hole 1 inch. The shearing strength of the rivets now becomes $R_s = 1^2 \times .7854 \times 2 \times 46{,}000 \times 1.85 = 133{,}700$ pounds, nearly, and the net width of plate required to furnish the same strength is $133{,}700 \div 45{,}000 = 2.971$ inches, or 3 inches, nearly. This corresponds to a pitch of $3 + 1 = 4$ inches, which is less than the assumed permissible maximum.

The question now arises: Will the efficiency be greater with this proportion than it will be if we use the next larger size of rivet and reduce the net section of the plate to a value that will give the greatest permissible pitch? With the permissible pitch of $4\frac{1}{4}$ inches the strength of the solid plate is $45{,}000 \times 4\frac{1}{4} = 191{,}250$, say 191,300 pounds. With a 1-inch rivet, the strength of the net section will be $(4\frac{1}{4} - 1\frac{1}{16}) \times 45{,}000 = 143{,}400$ pounds, and the efficiency will be

$$\frac{143{,}400 \times 100}{191{,}300} = 74.96\%.$$

With the $1\frac{3}{16}$-inch rivet and the pitch of 4 inches, the strength of the solid plate is $4 \times 45{,}000 = 180{,}000$ pounds. The strength of the joint is the same as that of the rivets; the efficiency is, therefore, $\frac{133{,}700 \times 100}{1{,}000} = 74.28\%$, very nearly. This is less than the efficiency with the next larger size of rivets and the maximum permissible pitch, and a little inspection shows that any smaller size of rivets would give a still lower efficiency. Also, since the 1-inch rivets are

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stronger than the net section of the plate with a pitch of 4 inches, we see that any attempt to use larger rivets with this pitch would only result in further reducing the strength of the net section and, in consequence, the efficiency.

If the pitch could be increased to $4\frac{7}{8}$ inches, so as to make the strength of the net section of the plate equal to that of the 1-inch rivet, the strength of the solid plate would be $45{,}000 \times 4\frac{7}{8} = 199{,}700$ pounds, and the efficiency would be increased to $150{,}900 \div 199{,}700 \times 100 = 75.56\%$. This, however, is contrary to the rule that was available for the greatest pitch allowable. We therefore see that the maximum efficiency that can be obtained *under the assumed conditions* is 74.96%.

The efficiencies of riveted joints that may be expected to be attained in practice average as follows:

For a single-riveted lap joint, 56%.
For a double-riveted lap joint, 70%.
For a triple-riveted lap joint, 75%.

For a double-riveted butt joint with two cover plates, 76%.

For a triple-riveted butt joint with two cover plates, 85%.

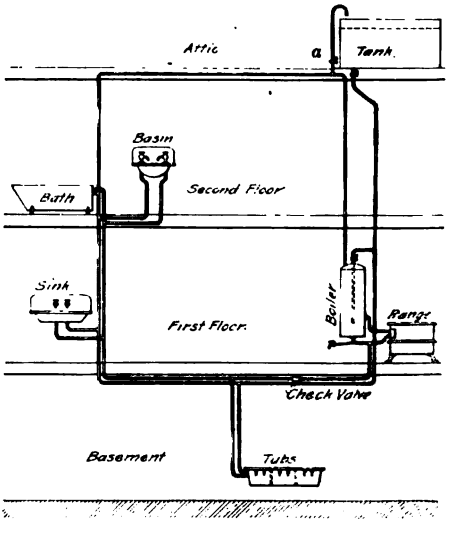
Single- and double-riveted butt joints with one cover plate give about the same efficiencies as single- and double-riveted lap joints.

The efficiencies given must be understood to be nothing else but *average* efficiencies; the reader must not fall into the error of assuming that because a lap joint is triple riveted it *must* have an efficiency of 75%. As a matter of fact, it may be slightly higher, and can be much lower. Hence, the efficiency should always be calculated by the rules given.

Numerous tests have shown the average shearing resistance of iron and steel rivets in single shear and per square inch of section to average, for iron rivets, 38,000 pounds, and for steel rivets 45,000 pounds, which values are commonly used in the absence of any other data.

CIRCULATION OF HOT WATER

IT IS a difficult matter to pipe a building so that the hot water can be drawn instantly at fixtures located at a lower level than that of the boiler. In such a case it is necessary to form a loop by running the hot-water pipe up as high as possible before descending to supply the lowest fixtures. A good example of this is shown in the accompanying figure, where the laundry tubs are located in the basement and the system is supplied from a tank in the attic. The hot-water distributing pipe forms a loop, the flow pipe of which connects to the top of the boiler, and the return end to the bottom. A half-inch relief pipe is located at *a*, which must be the highest point of the loop. This allows the air to escape from the loop, which would otherwise become air-locked. A stop-cock is placed at the base of the relief pipe as shown, which may, if necessary, be checked down to a very small opening to prevent air from being sucked into the cock while the hot water is being drawn at the fixtures. A check-valve fitted with a very light swinging valve is attached to the return pipe of the loop as shown, to prevent cold water in the bottom of the boiler from being drawn at the hot-water faucets of the tubs. Care must be



taken not to use a heavy check-valve here, for the force of circulation is not great enough to lift a heavy check.

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THE DESIGN OF HEAVY FOUNDATIONS

Maurice M. Sloan

THE BEARING VALUES OF DIFFERENT SOILS—THE DESIGN OF FOUNDATION PIERS—PILE FOUNDATIONS

FOUNDATIONS, which are certainly the most important part of any structure, should be properly proportioned, and too much care cannot be exercised in their design. They are required to sustain the maximum load to which they are subjected, and this consists of the dead and live loads. The full amount of the latter, however, is not usually considered in the design.

The accumulated dead load should first be ascertained, then that portion of the live load which it is deemed advisable to add to it, and the area of the footings and foundation piers so designed that the greatest pressure per square foot does not exceed the safe values given for the various soils in the following table:

Character of Soil.	Safe Bearing Value in Tons per Sq. Ft.
Compact bed rock of granite	30
Compact bed rock of limestone	25
Compact bed rock of sandstone	18
Soft friable rock	5 to 10
Clay in thick beds, absolutely dry	4
Clay in thick beds, moderately dry	2
Soft clay	1
Dry coarse gravel, well packed and confined	6 to 8
Compact dry sand, well cemented and confined	4
Clean dry sand, in natural beds and confined	2 to 4
Good solid dry natural earth	4 to 6

Where there is liability of the foundation soil being loosened by water or by adjacent building operations, due precautions should be taken to prevent serious results from such contingencies. Poor soils, wherever practicable, should be improved so that they are better adapted for foundations. Wet soils may often be considerably improved by drainage, and loose soils by ramming or by driving piles at intervals. All foundations, to be protected against frost, should be carried to a depth of at least 6 feet below the surface of the surrounding soil.

It is often necessary to build foundations on yielding materials, which will settle considerably, and great care should be exercised to have the settlement uniform. In order to obtain uniform settlement, the pressure on a unit of area must be the same under all foundation footings and piers, provided the nature of the soil is the same throughout the area covered by the building. Where the soil under different portions of the building is likely to have different bearing values, it should be carefully tested and the safe bearing values ascertained at several points throughout the foundation area, the foundation footings and pier foundations being so proportioned that the settlement will be as uniform as possible.

Where the actual live load is variable and seldom approaches the load originally assumed, as in office buildings, equal settlement of the foundations is usually attained by proportioning the areas of the footings so that the dead loads produce equal pressure. For example, the heaviest loaded fonndation pier in a building supports a dead load of 200 tons and also a live load of 200 tons, while another foundation supports a dead load of 100 tons and a live load of 150 tons. The first pier sustains a total load of 400 tons, and, assuming the soil to safely sustain a load of 4 tons per square foot of bearing area, the area of footing required for the heaviest pier, to carry both the dead and live load, is $400 \div 4 = 100$ square feet. This area gives, when estimating on the dead load alone, a bearing pressure of 2 tons per square foot. Using this unit bearing value of 2 tons for the second pier, the area of base required, figuring on the dead load alone, would be 50 square feet; while if both the dead and live loads were considered in proportioning the foundation, the required bearing area would have been 62.5 square feet, and the dead load would cause a pressure upon the soil under the second pier of only 1.6 tons, which would have a tendency to cause unequal settlement.

All foundation piers resting on soils of good dry natural earth having a safe bearing value of from 3 to 4 tons per square foot, should be designed as shown in the accompanying figure. It is well to compose the concrete base of 1 part cement, 2 parts sand, and 5 parts of broken stone small enough to

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pass through a ring 2 inches in diameter. The base should have such an area that the pressure per square foot upon the soil will not exceed its safe bearing value. The offset a of the concrete should not be less than one-half its depth, or thickness b, as designated in the figure, and the thickness b never less than 16 inches. It is well to make the body of the pier of a good quality of hard bricks laid in Portland-cement mortar, and the area of its base must be so proportioned that the pressure on each square inch of the concrete shall not be more than 200 pounds. The batter of the sides of the brick pier should never exceed a 6-inch offset to a 12-inch rise; that is, the rise must be in the ratio to the offset as 2 to 1. The area of the capstone in juxtaposition to the brickwork should be such that the safe bearing value of the brickwork is not exceeded. When the load on the capstone is great it is good practice to provide a heavy cast-iron pedestal so as to distribute the pressure equally over the capstone. In proportioning the area of the cast-iron base bearing on the capstone, care should be exercised that the safe-bearing strength of the stone is not exceeded. The maximum allowable pressures on the usual materials employed in the construction of foundation piers are generally taken at the following values in good engineering practice:

Granite	350 lb. per sq. in.
Limestone	300 lb. per sq. in.
Sandstone	250 lb. per sq. in.
Brickwork in Portland cement	200 lb. per sq. in.
Concrete	200 lb. per sq. in.

Capstones are usually cut from granite, limestone, or sandstone, and should have a minimum thickness of 1 foot, but its thickness in any case should never be less than one-third its greatest dimension, if rectangular, and one-fourth the length of its side if square. The cast-iron pedestal should have a height of one-half the greatest dimension of its base, and should be so proportioned that the pressure on each square inch of its minimum cross-section does not exceed 14,000 pounds.

The following problem is worked out as an example of the application of the foregoing information. It is required to design a square foundation pier of hard bricks with concrete footing, all laid in Portland-cement mortar. The capstone is of granite and supports a cast-iron pedestal, which in turn sustains a structural steel plate and angle column. The load on the column is 600,000 pounds, and the safe bearing value of the soil has been ascertained to be 3½ tons per square foot.

In this problem, the size of the cast-iron pedestal depends on the unit allowable bearing value of the capstone, which, according to the preceding table, is 350 pounds per square inch; then, $600{,}000 \div 350 = 1{,}714$ sq. in. required, and the dimensions of the base will equal $\sqrt{1{,}714}$, or approximately 42 in. on a side. The size of the granite capstone will be determined by limiting its pressure on the brickwork to 200 pounds per square inch, and the area required on the bed of the stone will equal $600{,}000 \div 200$, or 3,000 sq. in.; the length of its sides is $\sqrt{3{,}000}$, or 55 in. Its thickness will be one-fourth its base, or 14 in. The area required for the concrete footing is equal to $600{,}000 \div 7{,}000$, or 86 sq. ft., and consequently it should be 9 ft. 3 in. square, its thickness being 18 inches.

Since the sides of the brickwork are battered 1 to 2, and the dimensions of its top and bottom are known, its height will be found as follows: One-half the difference between the top and bottom dimensions equals $\frac{(111 - 18) - 55}{2}$, or 19 in. The 18 in the calculation is twice the offset of the concrete beyond the brickwork, which, as previously stated, should not be less than one-half the thickness of the concrete; in this case it is 9 inches. The batter is 1 to 2, and therefore the height of the brickwork is equal to 19×2, or 38 in. From the results of these calculations the design of the foundation pier, cap, pedestal, and foot of column may be drawn as shown in the illustration.

Pile foundations should be used where the soil is clayey and incapable of sustaining the desired load, or where there is a stratum of clay with firmer soil beneath. Timber piles, if properly driven and their location allows them to be submerged under water, are considered a satisfactory and permanent foundation.

All timber piles should be spaced from 2 feet to 3 feet between centers, and should be driven to an equal bearing, which is determined by the distance penetrated under the last blow of the hammer. The bearing load on piles driven to bed rock through stiff soil capable of providing lateral support, should be considered as equal to the direct safe compressive strength of the timber taken at the least cross-section. If the surrounding soil is plastic and incapable of furnishing lateral support, then the pile must be considered as a timber column of the same length as the pile. In determining its safe

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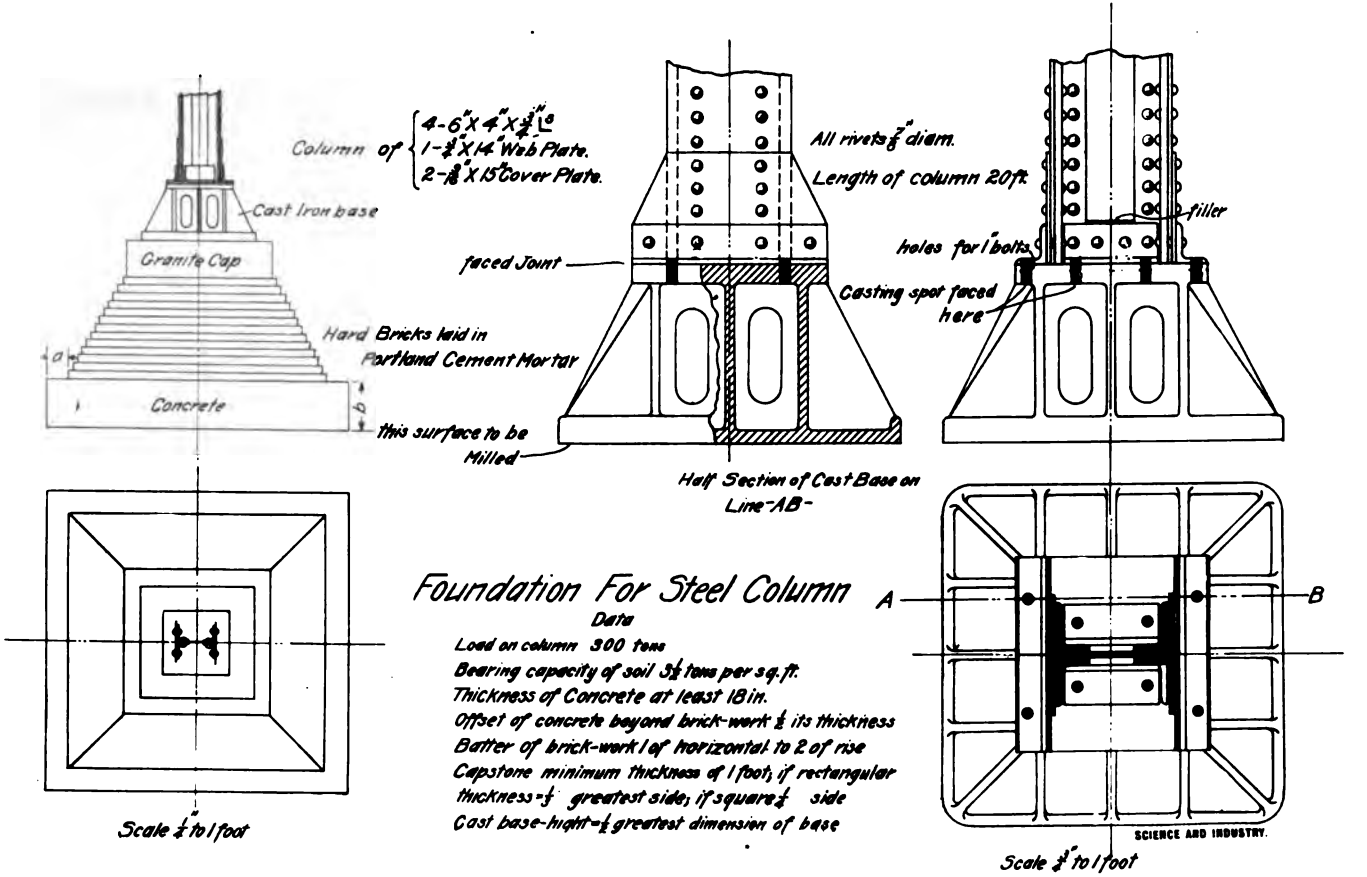

Foundation For Steel Column

Data

Load on column 300 tons
Bearing capacity of soil 3½ tons per sq. ft.
Thickness of Concrete at least 18 in.
Offset of concrete beyond brick-work ½ its thickness
Batter of brick-work 1 of horizontal to 2 of rise
Capstone minimum thickness of 1 foot; if rectangular thickness = ⅓ greatest side; if square ¼ side
Cast base-hight = ½ greatest dimension of base

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strength per square inch of cross-section, the formula $S' = \frac{SL}{8.33\,D}$ may be used. In this formula, S equals the allowable compressive strength of the timber in pounds per square inch, L the length of the pile in feet, and D the diameter of the column in inches. The allowable compressive values of the several kinds of timber used as piles may be taken from the following table:

	Per Sq. In.
White oak	800 lb.
Southern long leaf or Georgia yellow pine	700 lb.
Cypress	800 lb.
Chestnut	1,000 lb.
Cedar	800 lb.
Norway pine	800 lb.
Oregon pine	1,200 lb.

In locations where bed rock or hardpan cannot be reached and piles are driven through yielding material, they may be so loaded that the weight in tons upon them does not exceed the value of L in the following formula: $L = \frac{2\,WH}{P+1}$, where W is the weight of the hammer in tons, H the drop of the hammer in feet, and P the distance in inches penetrated by the pile under the last blow of the hammer. The value P must be considered only when the burred splinters have been removed from the top previous to the last blow being struck. The maximum load on any pile should under no condition exceed 20 tons, and the least allowable diameter of any pile is 5 inches. After the piles have been properly driven, the tops should be cut off on a level and capped with granite or concrete or provided with oak grillage, as thought expedient.

In constructing pile foundations, it is necessary to exercise great care in order to prevent the disturbing of adjacent building foundations. If it is found necessary to drive them close to existing foundations, especially if such foundations support heavy buildings and the surrounding earth is liable to considerable compression due to the superimposed load, such construction ought to be abandoned and the foundations designed in such a manner as to prevent the danger attending the disturbance of adjacent footings.

STREET-CAR WIRING

(Concluded from the November, 1900, Number)

Eug. C. Parham

THE DEVICES USED ON STREET CARS—POINTS ABOUT THE LOCATION OF EACH—THE SETTING UP OF CONTROLLERS—ARRANGEMENT OF DEVICES

THE devices on a car are of three kinds: power, heat, and light devices. The power devices are of three classes: operative, controlling, and protective. To the operative class belong the trolley pole and its equipment (consisting of the foot, base, harp, rope, and wheel) and the motors; to the controlling class belong the controllers and start coil, or resistance box; to the protective class belong the overhead switches, or automatic circuit-breakers, the fuse box, and the lightning arresters. The devices called for in the light circuit are wall sockets, or clusters, snap switches, and fuse boxes; and in the heat circuit, the electric heaters, a change switch to vary the amount of heat, and a fuse box. It is beyond the scope of this article to take up the description of the several devices or to offer any recommendations in regard to their selection, but inasmuch as it is the duty of the wireman or electrician to place them, or at least dictate where they shall be placed, a few timely remarks in regard to where and how they shall be located will not be out of the way in this article.

It sounds almost foolish to say that the trolley stand on single-truck and short

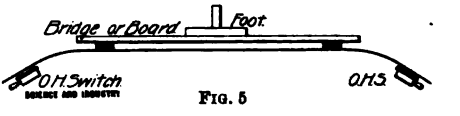

FIG. 5

double-truck cars should be placed at the center of the car roof. On long double-truck cars it is the practice to place the stand at a point several feet nearer one end of the car than the other, in which case the car is run around a loop at the end of the line. Where there is no loop or other means of turning the car around, two trolley stands must be used, placed at points equidistant

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from their respective ends of the car. Iron stand hooks must be provided at both ends of the car, to hold down the pole that is not in use. When the car is to run on a conduit system part of its route and on a double overhead trolley wire the rest of the way, double trolley stands are used, and two stand hooks must be used on each end, to hold the two idle poles down; but do not try to make the two hooks out of one piece of iron, for trouble will follow the first time the poles or plow come in contact with the live conductors. In any case, whatever may be the severe wrench, the lags will give way and liberate the stand without tearing up the car roof; between tearing up the car roof and letting 100 or more pounds of iron down on some person's head, the writer favors the former, and therefore advocates the use of bolts. Some stands have a projection on the under side of the foot, in which case the trolley board must be bored to let the bearing surface set down.

The overhead switch, variously called hood switch, main switch, bonnet switch, and canopy switch, is placed on the under side of

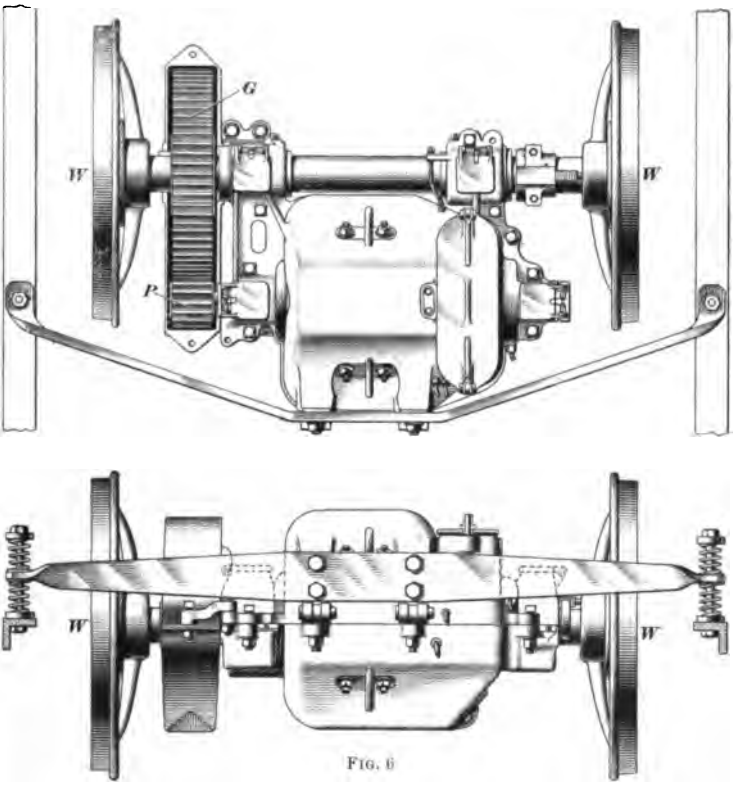

FIG. 6

number of poles called for, the foot of the trolley stand must be secured to the roof of the car. The foot of the stand is the lower stationary part around whose pin as a center the spring base turns. The foot is generally fastened to a board running along the car roof, as shown in Fig. 5, and is called the trolley board or trolley bridge. This device acts as a spring to cushion the reaction of the pole blows on the car roof. In some cases the foot is bolted to the board and in other cases it is secured with lagscrews, under the claim that in case the stand gets a

the car hood, just above and a little in front of the motorman's position, and must be so placed that almost the most natural or involuntary move of the motorman to that end will enable him to move the handle to the "off" position. There are always two switches to a car run from both ends, and under no circumstances should the position of the switches vary on any car on the road. If it does, there will be trouble some time. As a rule, the switch is mounted on a polished, hardwood beveled-edge board, and the board is screwed to the ribs of the car

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hood. This board should be ¼ or 1 inch thick, its other dimensions depending on the size and kind of switch used, and the distance apart of the hood ribs. Before putting up the switches they should be tried to see that the movement of the handle has the proper feel and that it does not stick. The best position for the overhead switch is indicated in Fig. 5.

The best place for the fuse box is some point as near as possible to the wire that comes through the car floor from the roof. On a closed car this would be on one of the outside platform sills, just behind the step. On an open car the fuse box can be put well back from the end of the car, on one of the intermediate sills, provided there is clearance enough between the step toe-board and the bottom of the car to allow a motorman to reach through and renew a fuse. It may be necessary to put the fuse box at the end, behind the step; no cast-iron rule can be laid down that will hold good in all cases, because the great difference in the under side details of the many trucks and bodies modifies the location of the available places. The two main conditions to be kept in mind are that the device shall be put where it can be easily reached without compelling the motorman to execute a serpentine dance; and that it shall be put where the blowing of a fuse will not alarm a passenger or scorch any clothes. If the fuse box is located where the motorman can reach it only by getting on all-fours, he will see to it that the fuse box is provided with a fuse that will never blow; if placed where the flash or heat of the explosion can affect a passenger, he or she, as the case may be, is very apt to jump and run the chance of breaking a limb. If it comes to a choice of any one of several good places, take the place that can be reached with the least amount of wire; but if there seems to be no place that fills the requirements of the above two conditions, create a place by means of a piece of board and an iron hanger to be screwed to the bottom of the car floor or to a sill or platform stem. In some shops it has been the practice to put the fuse box way around under one end of the car, just below the bumpers. This is not a good place for it, for, aside from the fact that it is a bad idea to put the box where the motorman will have to stand on the track to put in a fuse, it is liable to be damaged at any time by getting a poke from a misguided drawbar in coupling.

The choke coil, or kicking coil, or kicker, as it is variously called, is simply a few turns of the trolley trunk wire wound on a wooden core and interposed between the lightning arrester and the motors, to offer a further impedance to the passage of lightning through the motor circuit. The choke coil need not be over 12 in. × 4 in. over all, and it can be suspended from the car floor or a sill at some point near the arrester.

The one general condition to be fulfilled in placing a lightning arrester, is to have it where the wires that run from the fuse box to it and from it to the ground wire, can be run without any kinks or bends in them, as these work against the effectiveness of the device. There are two kinds of car arresters: one kind depends on gravity to reset the active member after a discharge, and the other kind does not. It is necessary, then, that the first kind be set up in a certain way or they will not work. One much-used method of setting up this vertical type of arrester is to mount it on a hardwood board to be screwed to one of the sills or cross-sills of the car. Where the arrester is rather high, as one reliable one in use today is, it may be necessary to cut a hole in the car floor to accommodate it. In this case the device projects half above the floor line and half below it. On closed cars it is installed under one of the side seats, while on open ones it is usually put under one of the end seats, inside or outside. There is no particular reason why the arrester should be put in an easily accessible place on the car, for up-to-date arresters do not need attention from any one but the shop man, and if the device is in good working order, it will go on and do its work with no noticeable demonstration.

The controller, or "motor box," as motormen sometimes call it, is the device that sets on the end of the car, and is operated by the motorman to start the car and control its speed. The principal condition to be fulfilled in setting up a controller is to so place it that the motorman can reach its handle and that of the hand-brake and operate them both in a natural manner, being neither cramped nor stretched when working both of them at the same time. The next point is to so locate it that the hole to be bored in the platform for the car wires to come up through, will not half cut one of the main platform stems. The top of the controller must come up at least flush with the top of the dash rail, so that in operation the dash rail may not interfere with the power handle. If the car is a closed one and has

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a vestibule, the device must set far enough back from the dash so that a heavily-gloved hand will clear the glass freely in turning the handle throughout its range. Even on open cars and on closed ones that have no vestibule it is a good idea to set the controller well back from the dash, so that when the car is run into the house to be painted or touched up and varnished it will not be necessary to remove the controller. Where a controller is too low to reach the top of the dash rail, it is raised by means of a wooden block under it. The block is cut to the shape of the controller base, is bored to let the car wires through, and is afterward given a coat of paint. Sometimes, instead of one large block, two small ones are used, one under each lug, or leg, of the controller. Even if the controller is high enough, it is the general practice to set it up on smaller blocks, as the increased height not only makes it easier to connect, but admits of insuring the end of the hose against the entrance of any water or snow that may accumulate on the platform. The controller is bolted to the car floor with bolts that pass through the floor, the iron lugs, and the wooden blocks. It is anchored at the back in either of two ways. On the back of the controller is always cast a boss to give stock for drilling holes to be tapped for about a ½-in. capscrew. One method of anchoring the frame is to run an iron strap from this boss to the dash rail. To get in the small bolt that holds the iron strap to the dash rail, the dash cap must be taken off and countersunk at the point where the head of the bolt falls. The other method is to run a yoke brace from the boss down to the floor, touching the floor about 8 or 10 inches from the controller, the two legs of the brace being shaped to bolt to the floor. In equipping a number of cars, it is a good idea to decide once for all where the controllers are going to set. Then actually set up one controller and, if the job is satisfactory in all respects, take the controller down and make a pasteboard pattern of the layout, to be used in setting up all of the others. This will save time and trouble and will obviate the necessity of fitting the iron straps or legs to each car. They can be all made at once. The iron straps used for fastening the controller back to the dash rail seem to have a special fondness for getting loose. In order to do away with this trouble, a square-headed bolt should be used and the dash cap countersunk to fit this square head, so that if the bolt does get loose the head will not turn when a wrench is applied to the nut. This will save taking off the dash cap.

The motors are mounted on the axles of the car and are supported partly by them and partly by steel bars running across from one side of the truck to the other, as shown in Fig. 6. These suspension bars should be so disposed as not to interfere with the opening and closing of the motor. Out of the shell of every motor come four wires called leads; two of these leads come from the armature and two from the field coils, and are the means of connecting the devices with the car wires. Great care should be taken not to confuse them, and they should be so supported that there will be no danger of their being cut, bruised, or torn apart.

This completes the locating of the several devices on the car, and defines the paths to be taken by the wires constituting the car wiring as applied to the main or motor circuit. It will not be out of the way to add that in placing the devices under a car, especially where the car is a double-truck one, equipped with air and with gas for lighting, so that there must be several tanks, etc. in the equipment, they should be placed with the idea of keeping the body, as a whole, well balanced, so that there may not be any more pressure on one set of rib plates than there is on the other. This is a point too often neglected, and is one well worth looking after. Also, on double-truck cars it must be borne in mind that in rounding curves the truck undergoes a great deal of displacement. This must be allowed for in placing the various wires and devices so that they may not be interfered with by the truck when it swings.

We will take up the subject of the wiring proper in a subsequent paper.

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PIPING FOR STEAM-HEATING PLANTS

Chas. J. Mason

ARRANGEMENT OF THE PIPES—THE DIFFERENT SYSTEMS—APPARATUS FOR THE CIRCULATION. TECHNICAL TERMS IN USE

THE usefulness of steam piping is not confined to central lighting and power houses and small plants of manufacturing concerns, but may be extended to the modern office building and even to private dwellings, for open fireplaces have had their day and been succeeded by modern methods of heating.

Strictly speaking, the arrangement of piping in a heating plant is more intricate and requires more thought and better judgment than that between the boilers and engines in the ordinary plant. Every building has its own peculiar style and method of piping for either the high-pressure, the low-pressure, or the exhaust-steam system. Exhaust steam is extensively used for heating purposes because of the economy of using steam that would otherwise be wasted by a non-condensing engine.

Where condensing engines are in use, live steam may be employed for heating parts of the building by installing in the system a reducing valve through which steam flows at a lower pressure than that in the boilers. An inexpensive and rough-and-ready method of supplying live steam at a reduced pressure to the heating systems of small factory plants is to use a ball-and-lever safety valve instead of the regular reducing valve. This safety valve, set at a predetermined lower pressure, is placed just ahead of a steam valve, as shown in Fig. 1, and by this arrangement the quantity of steam admitted to the system can be controlled. If it is decided, for instance, to carry a pressure of 5 pounds in the heating system, the weight on the lever is set at a point where it will balance the given pressure. These levers are usually graduated and the corresponding pressure stamped on the side, so that it is an easy matter to properly locate the weight for any pressure within the range of the valve. The safety valve is used as a regulating valve for the system, and when it is opened the steam is allowed to circulate freely until the pipes are hot and the air and water have been expelled from them. When this has been accomplished, the supply of steam may be cut down until the pressure balances the safety valve. The arrangement works very well when the boiler pressure is constant (as it will be when a damper regulator is in use) and the condensation is properly taken care of. Of course, the condensation will have to be forced into the boiler, for the gravity return is out of the question unless the building is very high and the pressure low. There should also be a by-pass to the sewer on the collecting tank or trap, as this allows the heating system to be kept in operation while cleaning or overhauling any part of the apparatus.

It is not the intention to discuss here the different kinds of radiators employed for steam heating, but rather the methods and systems of piping and the radiation of heat. Buildings are supplied with steam heat by either the one-pipe or the two-pipe system.

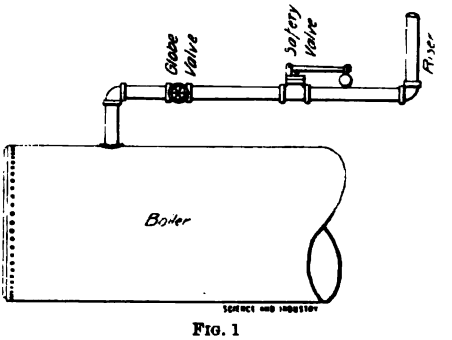

FIG. 1

In the two-pipe system there is one line of pipe for the steam supply to the different radiators and another for the return of the condensation, each radiator being connected to the two pipes. The one-pipe system, as the name implies, consists of a single line of pipe to which each radiator is connected. The condensation in this system will return by gravity direct to the boilers, because the water is heavier than steam and will fall to the lowest point, while steam will rise to the highest. The pipe in this case, however, must be one or two sizes larger than the one in the two-pipe system, in order to permit an uninterrupted supply and a perfectly free return of condensation. The size will depend on the number of heaters connected. It is usual, in this system, to have

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the radiators quite close to the pipe and connected by nipples and valves to tees, as shown in Fig. 2. In many instances this will necessitate the erection of a number of

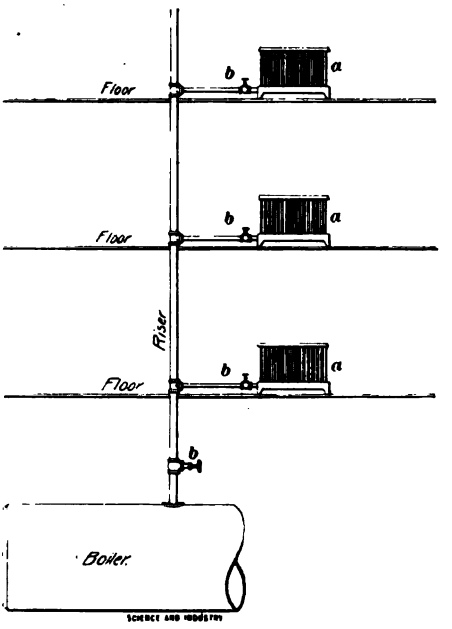

FIG. 2

pipes, in order that different parts of the building may be heated.

The systems mentioned may, by certain modifications, be subdivided into the "riser" and the overhead supply. By the first method the steam is carried upward to the branches connected to the radiators on the different floors. By the overhead system the riser is carried to the top of the building and then branched in different directions, drop pipes supplying the radiators on the floors below.

The radiators themselves may be direct, indirect, or direct-indirect. The direct radiator is so called because it is placed in the room to be heated; the indirect is placed outside of the room, the air heated by contact with it being forced into the room, which is thus indirectly heated. The direct-indirect radiator is a combination of the two others; it is placed in the room to be heated, radiating heat direct, and a current of air forced through it furnishes ventilation.

One other method of heating remains to be spoken of; this is sometimes called the "mechanical method" and by some is classed as indirect. The system consists of banks of steam pipes in a room in the basement of the building in which the plant is located; in this room there is also a fan blower, which draws the external air through a regular duct and forces it through the bank of hot pipes into the ducts for the various rooms. The amount of warm air admitted may be regulated by a sliding door. This is a system frequently installed in hospitals, because it takes up no space in the rooms, and because there is no noise from radiators or leaky valve stems or joints to cause annoyance.

When exhaust steam is used for heating, there is a back-pressure valve in the exhaust pipe which prevents the escape of the steam to the atmosphere and diverts it through the heating system. This valve may be raised at any time, to permit the steam to pass to the atmosphere when the heating system is out of service, as in the summer time. A back-pressure valve is, in some respects, like a safety valve of the weight and lever type, as any desirable pressure in the heating system may be obtained by moving the weight on the lever, just as is done with a safety valve. Of course, it will be understood that the range of such pressure is limited by the pressure of the exhaust issuing from the engine. It is desirable to have as little back pressure as possible, consistent with the existing conditions, since every pound of back pressure on the engine piston reduces the mean effective pressure in the engine. In some cases 5 pounds or more pressure above the atmosphere is necessary to maintain a circulation through the system, but 1 pound

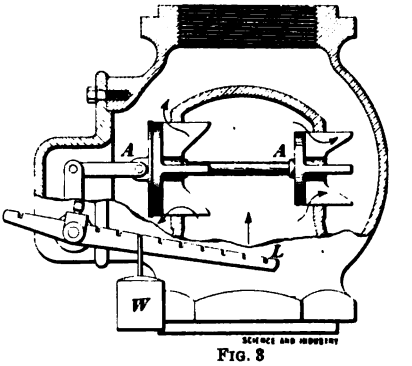

FIG. 3

is sufficient in a system having a vacuum pump. A pressure gauge is sometimes attached to or near the back-pressure valve so that the pressure may be seen at a glance, and if it is desired to change the pressure at

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any time the adjustment of the valve can be checked by reference to the gauge.

Before passing from this part of our subject it would be well, perhaps, to make mention of one particular kind of back-pressure valve in use. Instead of the flat valve and seat that usually hammers at each stroke of the engine, the one shown in Fig. 3 has a sliding valve that is noiseless in operation; it consists of two seats of different areas, and, instead of having to balance on the whole of the valve, as in some other makes, the force to be balanced is only that due to the pressure upon the difference in the area of the two seats.

There are many ways of arranging the pipes in the different systems, but the all-important consideration is that the pipes shall be of ample size for the particular system adopted, the amount of radiation required, the pressure to be carried, and the method of disposing of the condensation. It will be understood, for instance, that in the one-pipe system the piping must be of larger size than in the two-pipe system, because the condensation returns in the same pipe and in a direction opposite to the steam. It is also important that the returns shall be so arranged that there will be no "backing up" in the system. Speaking in general, the piping of the heating system in large plants should be divided into sections, the branches from each section of the main pipe being returned to a receiver common to all. This plan is advisable because of the possibility of parts of the system getting out of order and requiring renewal or repairs, and in such a case the whole system need not be cut out of service.

In regard to the selection of material, fittings, etc., it may be said that the best is none too good. Heavy pipes should be used throughout and placed in such a manner that all parts will be accessible with the least tearing up of the floors and opening of the walls. As far as possible, no perishable material should be used for joints, especially for the smaller sizes of pipe, but rather ground metallic joints should be selected. Such joints are, of course, more costly, but when they are once made up they seldom or never leak. For the joints of larger pipe, say from two inches up, rubber or its equivalent is admissible between the flanges.

Before concluding this portion of the subject, it may be of value to the reader to become familiar with the names of the different parts of a steam-heating system.

The *main steam distributing pipe*, as the name implies, is the pipe that supplies the whole apparatus through the various branches, and is usually run in a horizontal direction.

The *main return pipe* is the one into which all the return and drip pipes enter to carry the condensation back to the boiler. This is also run horizontally.

The *steam riser* is the name of the pipe that carries the steam vertically from the main referred to above to the radiator connections. A *return riser* carries the condensation back from the radiators to the main return pipe; it is also run in a vertical direction.

The pipes that connect the steam risers to the main and the return risers to the main return are called, respectively, the *steam riser connection* and the *return riser connection*.

Radiator connections are the pipes that run from the risers to the radiators, both for the steam and returns in the two-pipe system.

The term *rising lines* used by steam fitters, means both steam and return risers taken together.

Pitch is the inclination given a pipe to insure the proper flow of the condensation. In some systems (the one-pipe system, for example) the pipe should pitch toward the boiler, while in other systems it is desirable that the pipes should pitch from the boiler, so that the steam and condensation will flow in one direction to a point where provision is made for taking care of the condensation, while the steam continues on and up.

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WIRING A HALF-TIMBERED COTTAGE*

Thomas H. Cooper

THE UNLINED SINGLE-TUBE SYSTEM OF WIRING—SELECTING THE MATERIAL—RUNNING THE CIRCUITS—COST OF THE INSTALLATION

AS IN all concealed pipe work, unlined conduit is regarded simply as furnishing raceways for the conductors, and is not depended on to supply additional insulation. The lined conduit has an inner tube of insulating material $\frac{1}{32}$ inch thick, and in it can be used any good rubber-covered wire. A rubber-covered wire with an additional outer braid or covering $\frac{1}{32}$ inch thick, or equal to the insulation of the lined pipe, is used in the unlined conduit. The pipe in either case must not be smaller than $\frac{1}{2}$ inch, inside diameter, and the outer wall must be as thick as good gas pipe, so as to preclude all danger of its being punctured by nails or crushed in, thereby injuring the conductors or making the drawing of them difficult.

Unlined pipe is coated on the inside with an enamel, to make it perfectly smooth, so that the conductors can be drawn in with ease. Its advantages are that it is cheaper, easier to work, and the burning out of the wire does not usually injure it. The whole pipe system is installed without the wires, which are drawn in when the other work is complete. Standard dies and taps fit the pipe, and the work on it is done exactly as a good gas-fitting job should be done. The pipe is easily bent without filling, but regular elbows must be used where possible. Where the line crosses floorbeams, the beams are cut just deep enough to admit the pipe; when running in the direction of the beams and alongside of studding, a sufficient number of pipe straps or clamps are used to hold the pipe securely in place, and every outlet has an approved outlet box. The ends of the pipe should butt and be carefully reamed, and the joints made with white or red lead, thus keeping the inside smooth.

When the pipe system is completed it must be permanently grounded. The pipe must enter all outlet boxes and fittings and be securely fastened so that it cannot slip out of place. The best way to secure this result is to thread the ends of the pipes and make them protrude $\frac{1}{4}$ inch through the sides of the box and screw on a collar. These collars are covered with insulating material that keeps the insulation of the wires from being injured by the sharp edges of the pipe. The outlet boxes come in sections, with the holes in the bottom and sides stamped out and sealed with disks that can be removed with a blow of the hammer, and any desired combination may be procured. The boxes are also drilled and tapped to take blank ends, so that combination fixtures may be used and the gas side left blank. The holes may be used for a concealed rosette, from which the ordinary drop can be suspended. The same style of box may be used for flush switches, by using a special cover, which is attached by means of four machine screws at the corners of the box. When using gutter panel boards, the pipe enters the outer wall and protrudes $\frac{1}{4}$ inch through it; a collar is screwed on the pipe, and the wires are laid in the gutter in circular loom conduit. On this job the center holes in the bottoms of the outlet boxes will be used to pass the gas drops through. Between the beams and studding at every outlet a piece of board must be fitted and securely nailed in such a position that when the box is screwed to it the face of the box will come just flush with the plaster line.

The only difference between the single- and double-tube system is the actual work and the additional material. The principal reason for using the single-tube system in this case is that it is necessary on alternating-current systems to do away with the disturbing inductive action that takes place in the double-tube system, and as the current used may be either alternating or direct, or even changed at any time, it is recommended by inspection departments and engineers in general that this system be universally employed.

The tools necessary for the pipe work are a pipe vise, stock and dies, three wheel cutters, reamers, and pipe tongs. Various methods for bending pipe have been used and recommended, but the writer has found

*A description of the wiring of this cottage by the knob and tube system was published in the October number of this magazine, and in accordance with our purpose to give the wiring by both methods, we present the second article of the series by Mr. Thomas H. Cooper, showing how to do the wiring using the unlined single-tube system.

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by actual experience that for all practical purposes a block bored with a hole of sufficient size to allow the pipe to enter easily is

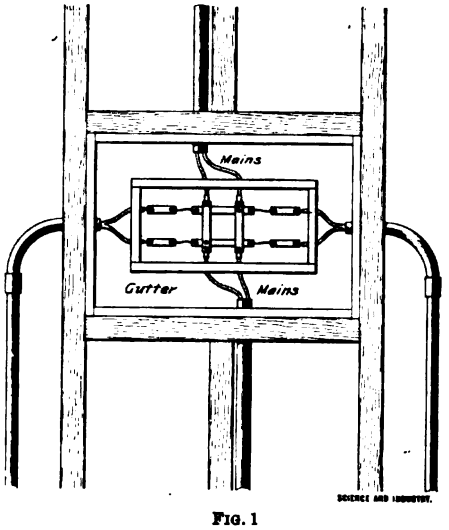

FIG. 1

as good as anything, but, like everything else, is not fool-proof.

Twin wire with an extra outer braid, as already explained, should be used, and each branch provided with a double-pole knife switch and fuse to carry 10 amperes; the panel boards should have center bus-bars of sufficient size to carry 50 amperes. The boxes are to be lined throughout with slate ½ inch thick, and the door may be either of glass or a solid panel, to match the trim of the house. In this job it is not necessary to have switches to control branches in the panel boards for the cellar and the parlor floor, as the branches on these floors are controlled by flush switches. If they are left out the cost will be reduced somewhat, but this will be more than overbalanced later on in making tests.

We will distribute the lights the same as when wiring the house by the knob-and-tube system, and therefore the size of the conductors will be the same—No. 8 mains and No. 14 branches — when wiring for direct-current 110-volt two-wire service. To change to three-wire direct-current service it will be necessary to add a third conductor and equip the panel boards with three center bus-bars and balance the circuits in the panel boards. For an alternating-current service of 100 or 104 volts no changes will be necessary, but for an alternating current of 50 or 52 volts the mains and branches must be increased in cross-section proportionately. We mention these changes for the reason that they are the conditions most likely to be met with.

The faces are removed from the panel boards and the boards and cases set between the studdings flush with the plaster line; when the house is trimmed the faces are replaced the same as any other trim. As the panel boards will be too wide to set between two studs, a place must be provided for them by cutting away a stud and placing a header at the top and bottom of the box, thus bringing the mains and branches as shown in Fig. 1. The panel board in the cellar may be placed in the ceiling in the line of the mains. This will save wiring, but if desired it can be set in the side wall and the mains carried over to it. The bus-bars in this board and in the one on the first floor must be provided with lugs at both ends, the mains entering at the bottom and leaving at the top. The board for the second floor requires lugs on but one end of the bus-bars, as the mains end here; if the third floor is wired it will be by a branch from this board. The mains are soldered in the lugs, but the branch wires are clamped directly under the binding screws.

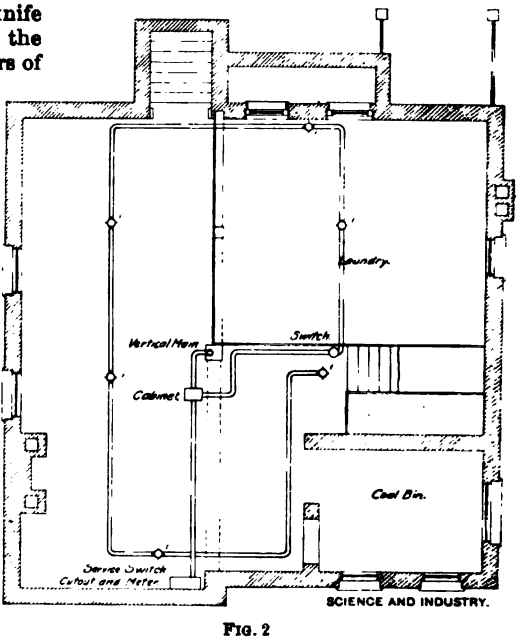

FIG. 2

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The circuits are all numbered, and a written or printed card giving a detailed description of the circuits and covered with clear mica or a thin sheet of glass is fastened inside of the panel-board door. In using the pipe, have as few bends and elbows as possible. The pipe should be run straight from outlet to outlet with not more than four elbows, not counting those at the outlets. Particular attention is called to this matter because it is frequently overlooked and often results in great trouble and expense in drawing the wires.

Now that we have a fair idea of the work in general, it will be well to go over the ground to get an idea of what material it will be necessary to order. The panel boards must be made to order from sketches, and as it will take some time to get them, our attention will be first directed to the number of lights and circuits and the distribution of them, which data will be necessary to give the specifications for the boards.

But one circuit is necessary in the cellar, as the plans call for ten 16-candlepower lamps or less. Four separate circuits will be required for the first floor, one for the hall, one for the dining-room, one for the parlor, and one for the rest of the floor. There are two separate circuits on the second floor, each of which will carry half of the lights. The panel board on this floor will require an additional blank circuit for the third floor; it is advisable to provide this circuit even if it is not used at once.

We will want, then, three panel boards of the following specifications: 1 with center bus-bars with lugs at both ends and 1 branch circuit for the cellar; 1 on the first floor for three branch circuits, with lugs on both ends of the center bus-bars; 1 on the second floor for three branch circuits, with lugs on the bottom of the center bus-bars. All branches are to be provided with double-pole knife switches and fuses to carry 10 amperes; the two center bus-bars are to carry 50 amperes. (The carrying capacity is made high for the sake of mechanical strength.) All metal is to be polished.

We will require, in addition to the above, 75 feet of No. 8 wire, 30 feet of ¾-inch conduit, and six ¾-inch elbows for the mains; 500 feet of No. 14 twin wire, 500 feet of ½-inch conduit, and thirty ½-inch elbows for the branches; 10 feet of ½-inch American circular loom conduit; 100 pipe straps; 40 Universal outlet boxes; 4 special covers for outlet boxes, to carry flush switches; 4 flush switches; tape, solder, acid, screws, and nails.

It is impossible to figure material exactly without plans drawn to scale, but it will be found that the estimate given above is a very close approximation.

Figs. 2, 3, and 4 are the floor plans. The figures marked at the outlets are the number of 16-candlepower lights allowed to each. If the cellar ceiling is to be plastered, the pipes must be put in place before the flooring is laid on the first floor; if not, the pipes can be strapped

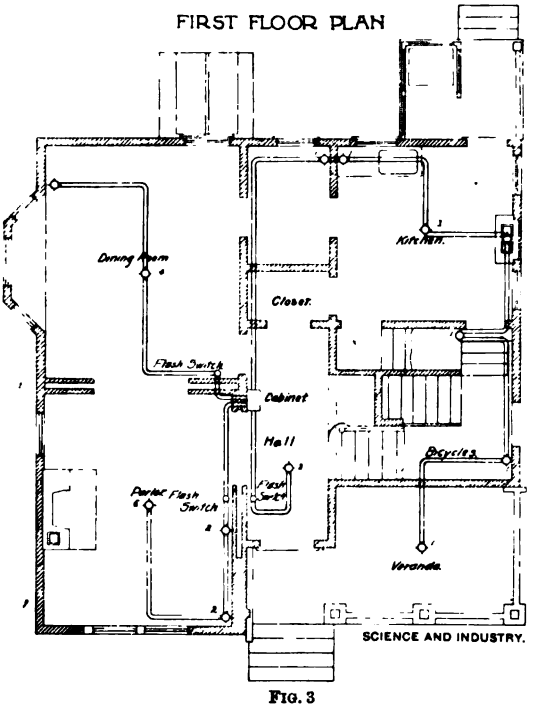

FIG. 3

to the faces of the floorbeams. The supply company will probably bring in the service from the street at the same place that the gas and water pipes come in, and will set their main service block and meter on the wall close to the gas meter. On the feeding side of the meter will be placed a cut-out large enough to carry all the current that the full load of the house will demand. The mains begin at the other side of this cut-out and are run back to the panel board for the cellar; they enter and leave this board as already described, and are then run to a point directly under the center partition

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of the house and in line with the center line of the partition separating the parlor and dining-room on the first floor, which is in the same vertical plane as the partition between the front and rear bedrooms

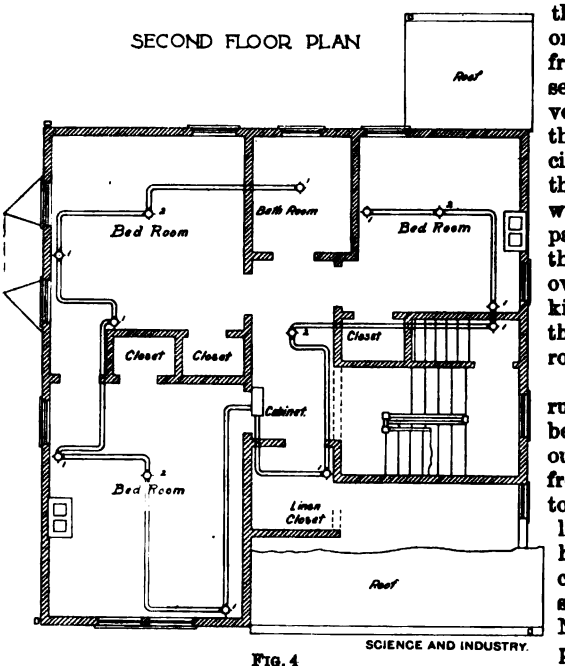

FIG. 4

on the second floor. The risers are then carried up to the first-floor panel board, which they enter and leave as they do the one in the cellar, and are then carried to the panel board on the second floor, where they end. All the cutting that will be necessary will be to notch each floorbeam in the cellar from the front wall to the partition where the risers are carried up. The bends at this point are made by means of pipes or elbows, and a hole is bored through the plate of the partition of the second floor for the pipe to pass through.

The ½-inch pipe in the cellar is run from the panel board to the partition at the foot of the stairs, where it enters the outlet box of a flush switch to control all the lights in the cellar, and from this switch it is continued to and through the outlet in the ceiling, in the manner shown in Fig. 5, and then to and through each of the others in the same manner.

The No. 1 circuit on the first floor is run from the panel board to a flush switch set in the trim inside of the folding doors in the parlor; from the switch it loops through the two side outlets to the one at the ceiling. The No. 2 circuit runs from the panel board to a flush switch set in the trim in the dining room, just inside the door from the hall; from the switch outlet it is continued to the ceiling outlet and looped to the one at the side. No. 3 circuit runs from the panel board to a flush switch set in the trim near the door from the veranda to the hall, and from there to the outlet in the hall ceiling. No. 4 circuit runs from the panel board to the rear of the house, on a line parallel with the center partition, then to the pantry outlet and continued in loops through the partition to the outlets over the sink, at the center of the kitchen, at the side of the range, in the pot closet, and in the bicycle room, ending at the veranda outlet.

The No. 1 circuit in the second floor runs from the panel board to the front bedroom, back bedroom, and bathroom outlets, as shown. No. 2 circuit runs from the panel board to the hall outlet, to the outlet between the storage and linen closets, back to the outlet at the head of the stairs, to the side and ceiling outlets, and ends at the rear side outlet of the back bedroom. No. 3 circuit is carried up in ½-inch pipe to the ceiling of the third floor, from there to the outlet in the front room and looped back to the outlet in the rear room.

It may be found of advantage in actual practice to change these runs slightly, but it should be kept in mind that, in all work of this kind, the object is to make the runs as short and straight as possible and that running between beams saves cutting. It will be found, however, that the runs cannot be made between beams as readily as by the knob-and-tube system, and when it is impossible to avoid cutting, keep as close to the supported ends of the beams as possible.

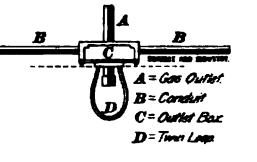

FIG. 5

As the conduit work is finished a steel tape called a "fish," or "snake," should be passed through each section of the pipe before it is closed in, to be sure that it is not clogged up. The wires can be drawn in much easier if a quantity of soapstone is blown through each section with a regular soapstone

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blower or a tin horn. The "snake" with a stout piece of cord attached, is worked through first, and the wire is then drawn in by the aid of the cord. After the wiring has been completed it should be tested for short circuits and grounds, but if the work has been properly done none will be found. The insulation resistance to the ground should be not less than one megohm.

The hanging of the fixtures is done after the house is entirely finished. They should be wired with special rubber-covered wire, not flexible cord, and equipped with lined key sockets and insulating joints. The fixture wires are soldered direct to the branch wires, the joint thoroughly taped, and the outlet-box opening and the wires concealed by the sliding canopy.

The cost of this installation can only be approximated, owing to the difference in the cost of labor and material in different places. In round figures, it should be from $200 to $250. It is the best class of work at the present time, and though it is costly it pays.

A few words in regard to flexible conduits would perhaps not be out of place here. A number of these conduits are now on the market, and they are easy to work and do well in some places, but as they are porous they are useless under cement and in damp places, as the cement when wet and soft works through and hardens in the tube, so that the wires cannot be easily drawn. A conversation overheard by the writer between a contractor and an inspector of the board of underwriters indicates the only way, in the estimation of the writer, to make a good job with this conduit. The contractor wanted to use flexible steel conduit under a cement floor not yet laid and asked the inspector whether he would pass it. The inspector replied that he would if it were installed inside of the regular pipe.

In a previous article on concealed knob-and-tube work and in this one we have applied the two best systems of modern electric-light wiring known, and explained the advantages and disadvantages of each. Either one makes a good safe job, and the hints and rules can be applied to any building with satisfactory results.

OIL IN STEAM BOILERS

W. H. Wakeman

THE UTILITY OF EXHAUST HEADS—CAUSE AND EFFECT OF OIL IN BOILERS—METHOD OF PREVENTING OIL FROM GETTING IN A BOILER

IN THE November number of SCIENCE AND INDUSTRY I described a small steam plant that is giving satisfaction to its owners, and showed a plan for taking the cylinder oil out of the exhaust steam. This I consider a very important matter, and, judging from the great variety of separators in the market and the number of them sold, others also consider the subject worthy of careful attention.

There are still many plants, however, in which little or no consideration is given to this feature, and as, in many cases, indifference to it is based on ignorance of the true condition of affairs, I desire to give my observation and the experience of others along this line. I cannot give my own experience with cylinder oil in steam boilers, because I have never had any. This is due to the fact that I have always taken precautions to dispose of it in other ways.

If the reader will stand close to the end of an exhaust pipe from an engine located in a plant where no separator is used, he will note that the steam, as it emerges from the pipe, is mingled with drops of water, which finally fall in miniature showers on the roof. After this has been going on for several months or years, the roof is thickly coated with cylinder oil, showing that much of it, instead of floating away with the steam, cleaves to the drops of water. The manufacturer of exhaust heads has discovered this fact, and advertises his product as capable of abating the nuisance by removing the oil and water from the steam.

An exhaust head does its work so well that a pipe must be provided to conduct the water to the sewer. If the steam user has one or more wells to supply him with water for making steam, or if he is supplied by the local water company for a fixed price per year, he is content to let this water go to waste, but if he buys it at a certain price per thousand cubic feet, he feels that he cannot stand the waste, and therefore provides some kind of a tank for the water to run into. He

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finds that pumping cold water through the feedwater heater condenses some or all of the steam when the pump is run at a fast speed, and as this water is going to waste

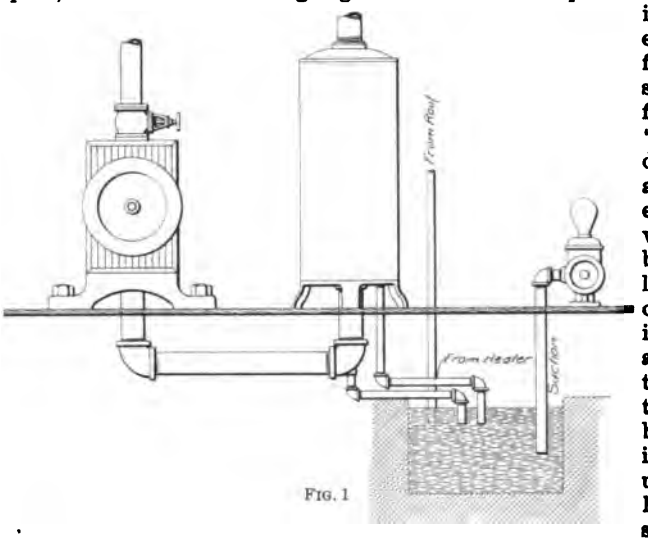

FIG. 1

through the drip from the heater, he causes it to discharge into the tank also. The heater is usually set on the engine-room floor or a few feet above it, so that it is necessary to put a drip into the lowest part of the exhaust pipe, and this discharges into the same tank.

Fig. 1 illustrates an arrangement that will be recognized as a very common plan, so far as the principle involved is concerned. If the engineer objects to it on account of the danger of getting oil into the boilers, he is told that the suction pipe of the pump extends down about half way to the bottom of the tank, and, since the oil rises to the top of the water, none can get into the suction pipe.

We all know that if any substance of a specific gravity less than 1 is put into water it will rise to the surface, but still the engineer soon discovers that oil is getting on the tubes and bottom sheets in such quantities that more fuel is required to keep up steam than when the boilers are clean, for oil, to some extent, prevents heat from passing through an iron or steel plate. Oil does not prevent heat from going into a plate, but does keep it from passing through the sheet into the water. This threatens the safety of the boilers, for the heat may weaken a sheet, when pressure will force it out of place, and a "bag" is the result. If this does not receive immediate attention, an explosion may ensue. The presence of oil where it is not wanted may be explained as follows: As long as all of the oil floats on the surface of the water in the heater, and as long as this surface is kept above the end of the suction pipe, there will be no trouble, but when the water level in the water tank is lowered until it is about the same height as the end of the suction pipe, the oil is at once drawn into the pump.

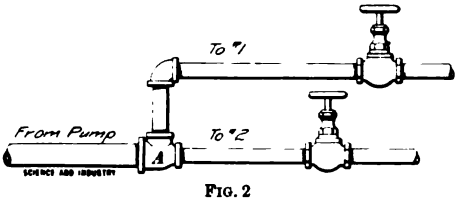

FIG. 2

Another source of trouble is the fact that all of the oil and grease does not go to the top of the water in the tank readily, because some parts of the oil are quite heavy. Much

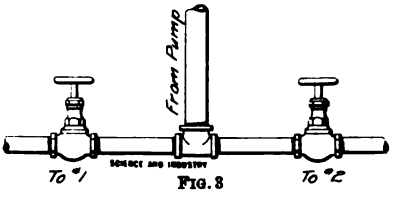

FIG. 3

of the lighter parts will go to the surface, but, as a rule, no provision is made for skimming it off, so that it stays there until dust and dirt collects on it and finally become mixed with it, forming a pasty mass that does not float; consequently this is drawn into the suction pipe and deposited on the boiler tubes and sheets.

The desire to save water is the direct cause of oil getting into the boilers, and the same consideration prevents it from being washed out as often as it should be, for the water contained in the boiler and that used through a hose to wash out the oil is deemed a loss that cannot be permitted very often.

I do not advocate the waste of water or heat, the latter of which means coal, but I do object to the crude plans made by incom-

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petent men who are sometimes allowed to erect plants in the way illustrated in this article, for they waste coal enough to more than pay for the water saved, and at the same time introduce an element of danger that should not be ignored.

In a certain plant, which consisted of two tubular boilers and a Corliss engine, that

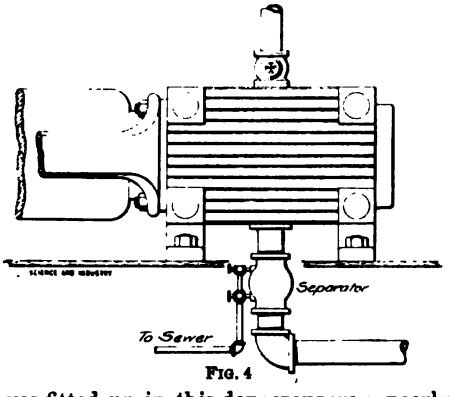

FIG. 4

was fitted up in this dangerous way, nearly all of the oil went into one boiler. While looking for the cause of this I found the feed pipes arranged as shown in Fig. 2. The mixture of oil and water was forced through the feed pipe by the pump, and when it reached the tee shown at *A* much of the oil rose to the highest point possible and consequently went into the No. 1 boiler. When the piping was taken down and arranged as shown in Fig. 3, the oil was distributed much more evenly.

By the adoption of the plan shown in Fig. 4, the water may be saved and the oil and grease sent to the sewer, where they belong. A separator placed in the exhaust pipe and close to the engine purifies the exhaust steam so that all of it may be condensed and returned to the boilers without danger of coating them with oil. If there is not room enough to permit it to be located as shown, it may be placed in the horizontal part of the exhaust pipe, but it should be as close to the engine as possible.

A few words of caution will not be out of place at this point. Some separators are undoubtedly better than others, and as the best are none too good, only those guaranteed to do the work should be used. All cylinder oils are not alike, some being compounded and others made of pure mineral products. When it is found by experiment that an oil can be removed readily from the exhaust steam, that is the kind to use, provided it is a good lubricant. The plan of changing cylinder oil frequently, for no reason but to save a few cents per gallon on the first cost, is not to be recommended, especially where exhaust steam is to be returned to the boilers.

POSSIBILITIES OF NEWS PRINTING

Geo. E. Walsh

AN AUTOMATIC DEVICE FOR TYPEWRITING TELEGRAPH MESSAGES—ATTACHMENTS TO OPERATE THE KEYBOARD OF A LINOTYPE—IMPROVEMENTS IN STEREOTYPING

THE printing room of a great metropolitan newspaper offers a fine illustration of the value and economy of machinery employed in the arts and sciences The evolution of printing in the last decade has been more interesting than at any previous epoch of its history, and the completion and operation of the wonderful modern giant presses, with a capacity of twenty thousand copies an hour, mark the acme of invention in this line. The success of these machines has been one of the marvels of the age, but there are still possibilities in news printing that open up new fields never before dreamed of. Speed and accuracy are the great essentials of a well-equipped newspaper office, and the perfection of the machinery has always been toward the accomplishment of these two objects. The newspaper has become largely the product of the machine, and only the intellect that directs it seems beyond the control and operation of machinery. The typesetting machine works with almost human intelligence, and performs work that the deftest fingers can never hope to equal.

But automatic news printing has not yet reached the perfection desired, and experiments and inventions recently made in this direction indicate that in the near future a new revolution will be recorded. Electricity has already manifested itself in this new field, and it will be through the application of this to printing that will make the change

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possible. In spite of the machinery in a printing office, there is still a good deal of manual labor to perform. Manual labor is always slower in producing anything than automatic machinery, and it is the ambition of inventors to do away with as much of this manual labor as possible, both to reduce expenses and to increase speed.

One of the impending changes in the printer's art is found in the automatic telegraph-typewriter, which has recently received considerable attention from the press and public. This automatic device is intended to combine the telegraph with the typewriter, and to save the telegraph editor a world of labor late at night, when everybody is in a hurry to put the paper on the press. Most of the news printed in a newspaper comes from the reporters, who write up all the local items of importance, and from telegraphic correspondents and news bureaus. At night the telegraph operator's room in a newspaper office is a busy place. The news pours in over the wires from a dozen different centers of the world, and as fast as the messages come clicking over the machine the operators write them out in long hand. Perhaps a dozen operators will thus be busily engaged for several hours, and it requires expert writers to take messages as fast as they come. The manual effort of writing out these news dispatches late at night is great. In some offices the typewriter is used for translating the telegraphic dispatches, and as the news comes from the telegraph sounder by his side the operator can translate about thirty words a minute.

By means of the new telegraph-typewriter, invented by Donald Murray, the news over the telegraph will be automatically reproduced on a perforated tape at the rate of 114 words a minute. This will be nearly four times as fast as the long-hand writing of the operator. This of itself would simplify newspaper telegraphic dispatches, but it would not be sufficient to overcome all the difficulties experienced.

Another step has been made in the system by which the linotype machine is operated at the same time. The keyboard of the linotype is operated the same as that of a typewriter, and by means of the new attachment this keyboard is worked by the telegraph itself. When a message comes over the wire this new attachment not only perforates the tape to indicate the message, but it operates the linotype keyboard and causes it to set in type the message sent. This change will enable messages from Washington or Chicago to pass straight from the wires to the type. There will be no operator to take down the messages and transcribe them. The new telegraph instruments with the typesetting attachments will be placed in the type-room instead of in the special telegraphic room, and messages will flow freely from the wires to type ready for instant use.

The messages from the wires are written on the tape first, and this tape is carried into the linotype, where the perforations automatically work the keys. The work can go on at the rate of 100 words a minute, and the telegraphic dispatcher in Washington can not only typewrite his messages in New York, but can actually set them in type there at this astonishing rate.

These inventions will also revolutionize the reportorial department of newspaper work. It has been commonly said that the typewriter was gradually driving the pen out of business and that in time it would take its place. The new inventions will practically drive the pen and pencil out of the newspaper offices. The reporter will no longer write out his copy in long hand and pass it on to the typesetter. Instead, he will write it out with one of the new tape-perforating machines, which will print the usual typewritten page and the perforated tape for the linotype. This tape is run into the linotype, and should any alterations of the copy be necessary, they can be made by simply pulling the tape along and operating the linotype by hand until the desired correction is made, when the tape resumes its work and the message goes on as before, the type falling into position with the regularity of clockwork.

Another invention that is intended to supplement typesetting by telegraph in the rapid production of a newspaper, is an automatic stereotyping machine. Stereotyping has heretofore been slow and clumsy work, and improvement in this particular has been urgently demanded. The new machine does in fifteen seconds what was previously done by three men in one minute, and the minutes saved in making a stereotype plate are of the utmost value when the last cast is to be made, since they reduce the interval between the setting of the last type and the printing of the paper to the smallest limits.

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CONSTRUCTING A SHEET-METAL CUPOLA

(*Continued from the October, 1900, Number*)

William Neubecker

Constructing the Cornice of the Cupola and its Supporting Corbel Table

THE next piece of work to be considered is the construction of the mold around the upper part of the cupola shown in Fig. 2. The miter cut for this mold must be obtained, and the method employed is the same as that used in laying out the stretchout and the miter cut for the base mold, which was described at length in connection with Fig. 4, in the July issue. When the pieces for this mold have been formed, they are set together in halves, and nailed against the sheathing of the cupola, the portions resting on the capitals being soldered. The two seams are soldered when the mold is in place, after which the flat sheet-iron ceiling is nailed in position with 1-inch wire nails. Flat iron used for a large surface is apt to buckle, and should be crimped or corrugated to avoid this disadvantage. The main cornice shown in section from *K* to *L*, Fig. 2, will be made in the shop complete in halves. The method of making the horizontal joints in this cornice, laying out and cutting the semicircular dentils and drips, shown by L^1 in Fig. 2, may now be considered.

We will assume that (*a*) in Fig. 24 represents the full-size detail of the main cornice, and that the seams will be located at *a*, *b*, *c*, and *d*. The dentil *e* has a 2-inch face, and is 3½ inches high and 2 inches deep. To lay out the patterns for this, obtain a piece of metal 3½ in. × 6 in., with square corners, as shown at (*b*). The required number from this pattern can be cut on the squaring shears from scrap pieces of metal, after which they may be prick-punched through the holes left in the pattern, as at *e*, *e*, in (*b*), Fig. 24. They can then be bent up on the small cornice brake, as shown in Fig. 24 (*c*), and the bottom *k* soldered in as designated. The dentil block at the corner of the octagon is peculiar, having two faces, as shown in Fig. 24 (*e*). It is necessary, in making this pattern, to get out a piece of metal 8 in. × 3½ in., marking it off as shown at (*d*). Of this pattern 8 will be required, formed as shown at (*e*), and with a flat head soldered in one end. To obtain the pattern for this head, draw an octagonal angle as *l*, *r*, *m*, in Fig. 24 (*f*), making *l r* and *r m* each equal to 2 inches, and at right angles to *l r* and *r m* draw the lines *l o*, *m n*, each 2 inches long, which is the depth of the dentil. Complete the figure by connecting the points *o p* and *p n*. Before laying out the pattern for the drops under the corbel table supporting the cornice, shown at *v*, Fig. 2, the true length on the line of the corbel table must be found,

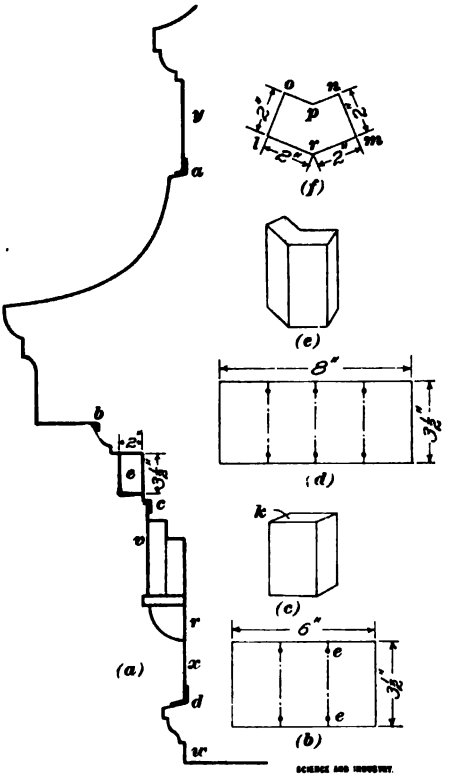

FIG. 24

so that the correct dimensions of the arches can be obtained. Upon referring to the section, Fig. 2, it will be seen that *w*, *x*, and *y* are in one plane, so that all measurements obtained on the line at *w* will also be the measurements on the line at *x* and *y*. As the distance from the center of the column to the point *w* is 6 inches, lay off, as in Fig. 6, this distance toward the outside from the

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center of the column, and draw a line parallel to *ef*, which in Fig. 6 represents the center line of the columns. This line just drawn intersects the miter lines *ch* and *cj*, and may be designated as *op*, which upon measurement is found to be 3 feet 9 inches long. All the measurements may now be taken on the miter cuts, measuring from the points shown at *w*, *x*, and *y*, Fig. 24, and the various patterns laid out by the method shown in connection with Fig. 7. Referring to the elevation, Fig. 2, it will be noticed that the plane of the corbel mold as indicated on the section *v*, Fig. 24, projects 3 inches outside the line *r*, and as it is important to obtain the length on the line *p*, it is necessary to mark a distance of 3 inches outside of the line *op* in Fig. 6, and draw through the point thus obtained a line parallel to *op*, as shown by *kl*. The length of this line upon measurement will be found to be 3 feet 11½ inches.

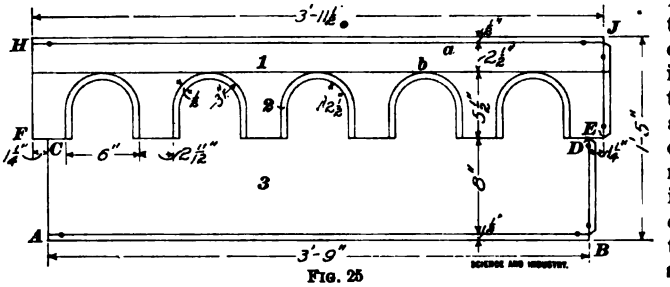

FIG. 25

Everything is now ready to lay out the pattern for the arches shown in section in Fig. 24 (*a*), from *c* to *d*, and in elevation in Fig. 2, at *a'*. From Fig. 2 it will be noticed that the width of the facia of the cornice upon which the corbel table is secured is 1 foot 4 inches. This being the case, obtain a sheet 1 foot 5 inches wide and scribe off on the top and bottom a ½-inch lap, as shown in Fig. 25. On the line *A B*, measure off the distance of 3 feet 9 inches, as before obtained in Fig. 6, and at right angles to *A* and *B* draw the lines *A C* and *B D*, equal in width to 8 inches, which is the distance from the top of the foot mold to the top of the corbel or drop in Fig. 2. As the length of the plane surface *v* measures 3 feet 11½ inches, lay off on a line drawn through *C D* extended, 1¼ inches on each side, as shown by *E* and *F*. At right angles to *E* and *F*, draw the lines *E J* and *F H*, until they intersect the ½-inch lap scribed at *H* and *J*. Then will this figure be the outline of the pattern for that portion of the cornice shown by *a'* in the elevation, Fig. 2.

As the distance from the top of the corbel to the top of the semicircle or arches is 5½ inches, and the distance from the top of the arch to the bottom of the dentil course 2½ inches, measure, in Fig. 25, 2½ inches downward from *a* to *b*, and draw a line on the sheet of metal as shown. The length from *H* to *J* equals 47½ inches, and the semicircles are 6 inches in diameter, 5 being required. The semicircles will then occupy 30 inches of space; this, when deducted from the length, 47½ inches, leaves 17½ inches, which is to be divided into 6 parts, making each part 2¹⁵⁄₁₆ inches wide, which is the width of the raised portion between the arches. Lay off on a line drawn through *F E*, in Fig. 25, these various spaces as shown. Bisect each of the 6-inch spaces, and setting the dividers to a 3-inch radius, scribe semicircles at the proper height representing the arches. As the inner semicircle forming the arches is ½ inch in, set the dividers to a radius of 2½ inches, and describe the inner semicircle as designated. Three patterns are now made from this layout, which, when cut, will be as shown in Fig. 26. Seven more pieces of metal like each of these patterns will be required. After the 8 sides have been cut, and the burr straightened on the square head with a mallet, they are

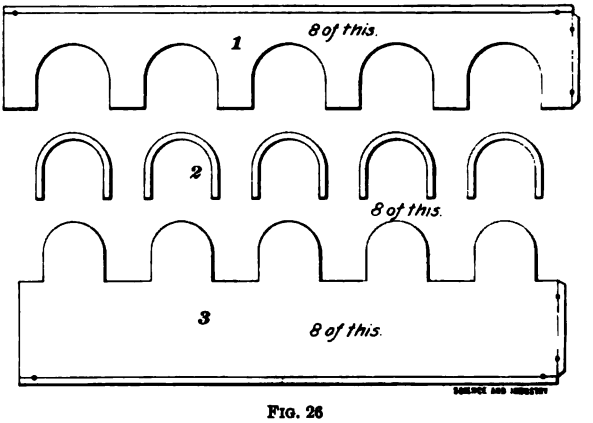

FIG. 26

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stripped, as shown in Fig. 27. The parts marked *1*, *2*, and *3* are the same as those similarly marked in Figs. 25 and 26. In a section through *e f* which is shown at (*a*),

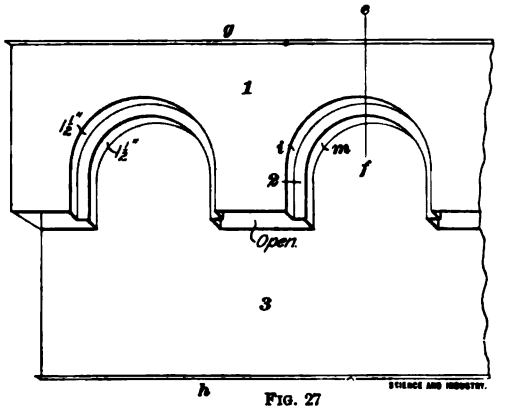


FIG. 27

Fig. 27, is designated the method of stripping; *a*, *b*, and *c* are soldered raw edges, while at *d* a ½-inch edge is notched and turned, and the portion *3* laid on the edges or lap and soldered. Each of the strips are 1½ inches deep, thus making the projection from the surface *1* to the surface *3*, 3 inches, as required. When soldering the strips in Fig. 27, the strip *i* is first soldered to the portion *2*

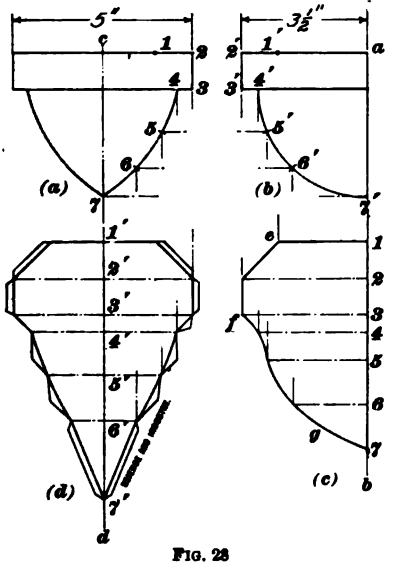


FIG. 28

on the outside, then the inner strip *m* is also soldered to the same portion on the inside. The section thus completed is soldered to portion *1* on the inside, after which part *3* is laid over the lap and soldered as before explained.

The next step is to prepare the corbels, which must be placed on that part marked *open* in Fig. 27. Referring to Fig. 25, it will be observed that the width at this point is marked 2½ inches, though in this case it will be considered as 3 inches. From Fig. 24, it will be observed that the sinkage in the arches is 3 inches, while the corbel projects ½ inch from the line *v*, as shown, thereby making the face of the corbel at the top 3½ inches from the face *r w* of the cornice, while the front of the corbel will be 5 inches wide. Therefore, in Fig. 28, draw the front and side views of the corbel as shown in this figure at (*a*) and (*b*), (*a*) representing the front view and (*b*) the side view. Since the length of the front and the sides of the corbel cap are unequal, separate miters will be required, one for the front and one for the side. In order to determine

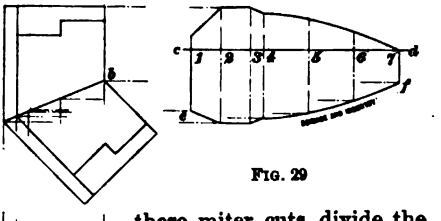
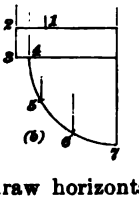


FIG. 29



these miter cuts, divide the side profile of the front view, (*a*), Fig. 28, into equal spaces, allowing the flange to turn inward on the top about 1 inch, as shown. From these spaces, numbered from *1* to *7*, draw horizontal lines intersecting the side view (*b*) at the points designated from *1′* to *7′*. In order to obtain the pattern for the side, place a stretchout of the side profile of (*a*) on the line *a b*, as shown in (*c*) by the figures *1* to *7*. At right angles to *a b*, and through the same figures, draw lines which intersect with the lines drawn from similarly numbered intersections on the profile (*b*). The latter are drawn downward and parallel to *a b* as shown, and a line traced through the points thus obtained is as designated by *e f g*, and will be the pattern for the sides of the corbel, of which 80 pieces will be required, 40 formed right and 40 formed left.

For the pattern of the front, place on the

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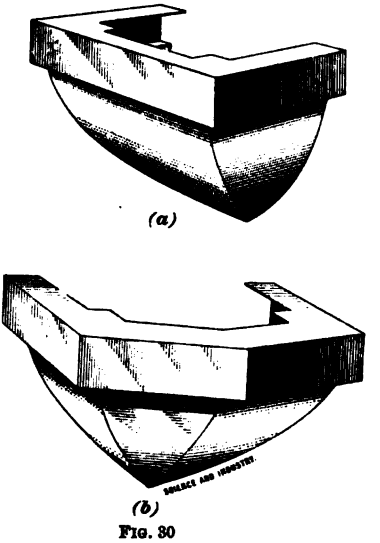
center line extended, as at *c d*, in the diagram (*d*), Fig. 28, the stretchout of the profile shown in (*b*), transferring each and every space separately, as the divisions on this profile are unequal, and proceed as previously explained in connection with the side pieces; 32 from this pattern will be necessary. For the pattern of the corbel at the octagonal corners, draw a correct plan of the corner corbel, as shown in Fig. 29, and in its proper position place a duplicate of the profile (*b*) shown in Fig. 28, and designated at (*b*), Fig. 29. Divide the profile into equal spaces, as shown by the figures *1* to *7*. Through these figures draw the vertical lines intersecting the miter line *a b* as shown. Draw in a horizontal line,



(*a*) (*b*)

FIG. 30

as *c d*, upon which place the stretchout of the profile (*b*), as shown from *1* to *7*. At right angles to *c d*, and through the points thus numbered, draw lines which intersect with those drawn from similar intersections on the miter line *a b*. These lines are drawn parallel to *c d*. By tracing a line through the points thus obtained, as shown from *e* to

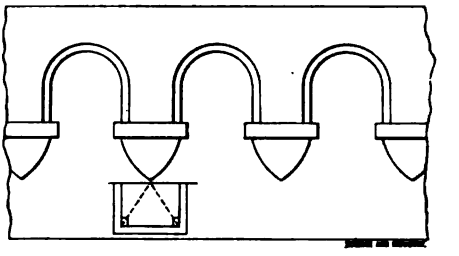


FIG. 31

f, the octagonal miter cut will be obtained. From this pattern, 16 pieces cut from sheet metal will be required, 8 with and 8 without laps, formed right and left. When all of these corbels are formed, the square corbels are set together as shown at (*a*), Fig. 30, leaving an opening at the top, as designated, and having the one-inch flange all around. The corner corbel is set together in a similar manner, as at (*b*), Fig. 30, the 1-inch flange being provided in this piece as well.

When the corbels are finished and the arches have been stripped, the corbels are then set in position between the arches where marked *open* in Fig. 27, and when in position will look as designated in Fig. 31. The various sections are now soldered or riveted together, to complete the full height of the cornice. When it is set in two halves in the shop and braced, it is ready to be sent to the building. In erecting this piece of work, it is set over the wood sheathing and fastened with wood screws, being nailed along the bottom, at *t* in Fig. 2, with 1-inch flat-headed wire nails. The two seams are put together at the building, and must be well soldered to avoid any leakage.

(To be Continued.)

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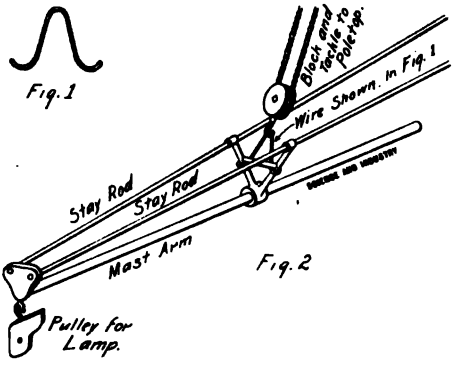
USEFUL IDEAS

HANGING MAST ARMS FOR ARC LIGHTS

C. H. Bell

THE hanging of a mast arm is usually an awkward job to accomplish, as many that have tried it have found. The following short description shows how we have got around



the difficulty after a number of trials and experiments.

A piece of No. 6 iron wire is bent as in Fig. 1, and when we are ready to hoist, the arm is placed in the V-shaped part of the arm, as in Fig. 2, and the hook from a small block and tackle hooked into the angle, the other end of the block and tackle being fastened near the top of the pole. The arm is then hoisted to its place and held while the cross-arm is secured and the stayrods fastened.

TEMPORARY REPAIR FOR A PISTON RING

Thos. C. Hulton, Thurmond, W. Va.

WHILE reading SCIENCE AND INDUSTRY a short while ago, I was reminded of a good method for temporarily repairing a piston that, on account of poor rings, allowed steam to pass. While running a worn-out pump that was continually breaking down, I noticed that the steam cylinder was consuming too much steam for the amount of water discharged. On removing the piston I saw that the rings did not fill up the cylinder. But how was the defect to be remedied with the tools usually to be found around a mine pump? As a forlorn hope, I tried the following: I removed the rings and with a sharp pocket knife cut a strip of cloth from an old pair of overalls, to fit the ring grooves, put the rings back in place, and replaced the piston. I started up the pump and awaited developments. I am still waiting, for that old piece of duck is still in for all I know, and it worked all right as long as I ran the pump.

CLEANING DRAWING INSTRUMENTS

W. M. Gilbert, Bethlehem, Pa.

A CHEAP and effective way of cleaning drawing instruments is to use a set of ordinary ink and pencil erasers. This is a method that has proved very satisfactory to me, and as I have never heard of it before, I send it to you in the hope that it may be of service to others. I first use a Faber's improved ink eraser and then polish the instrument a little with a Tower multiplex. Care should be taken when using the ink eraser not to scratch the piece, which may be done by rubbing too hard.

CASTING UNDERCUT PINIONS

E. W. Bentel, Washington, Pa.

A SHORT time ago I had occasion to make a drawing of a 12-tooth cast-iron pinion of 1-inch pitch. I laid it out by Grant's involute odontograph. After the pattern was made, our master mechanic informed me that it would be a hard matter for the foundry to cast it, as they always had trouble in casting pinions that were undercut. I hardly knew what to do, as I knew of no way to make a pinion that had so small a number of teeth without undercutting.

But we did cast the pinion with the original pattern, as described below, with very good success.

The pattern of the pinion was placed on a smooth surface plate and a border put about 1 inch away from the gear; then a casting of old Babbitt metal was made about ½ inch thick, making a kind of internal gear. This internal gear of Babbitt metal was trued and placed over the pattern; then, by carefully pulling the pinion pattern out of the sand through the Babbitt metal, a perfect mold was made. The casting was very smooth, with sharp corners.

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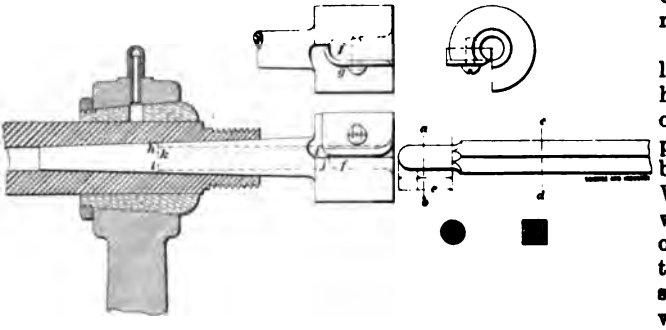
The master mechanic informed me that it works admirably, runs as smooth as a cut gear, and has very little lost motion. I always make cast gear-teeth on the pitch line $\frac{.775}{1000}$ times the pitch, and the space $\frac{.225}{1000}$ times the pitch.

No doubt this process might be old to some of the older mechanics, but it is new to me and might be the same to some of the readers of SCIENCE AND INDUSTRY.

ANOTHER DOWEL CUTTER

J. D. Hoffman

HAVING noticed an article on dowel cutters in the July number of SCIENCE AND INDUSTRY, I would like to call your attention to a cutter made in the Purdue University shops.



This cutter is designed to make pattern pins for split patterns. There is nothing especially new about it, as cutters of similar form are used in hand lathes, but its application may be of some benefit to woodworkers that have never tried it in this way. The expense of making is not great, and in time it will more than pay for itself. The cutter is made of steel throughout, and when used, it is substituted for the live center of the lathe.

In making the pin, the wood is sawed square to the size of the required pin diameter and held by the hand while the pin is being formed. A finished pin is shown in the sketch. This is sawed off to the length *e* and inserted in the pattern to the requiried depth.

A cutter for long dowels could be made at less expense than the one shown. The one thing necessary, of course, would be a lathe with a hollow spindle. Such lathes are to be found in most establishments.

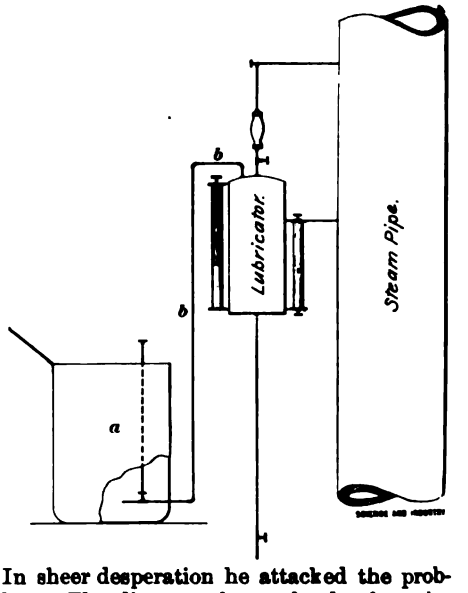
A cutter of this sort would require a straight knife instead of the one shown, also a hollow stem. The stem could be made shorter and not lessen the efficiency of the tool. The changes are indicated in the dotted lines *h*, *i*, *j*, *k*, *l*. I have found the tool to be very valuable.

A NOVEL FILLER

W. McNeill, Chicago, Ill.

A LUBRICATOR without a filling attachment is incomplete. That engineers should go on all these years operating their lubricators in the crude, wasteful, and exasperating method now generally employed, is a very strange thing. Necessity is, in truth, the mother of invention, but in this case she has been a very long time in bringing forth her offspring. For more than 20 years some neat, clean, and easy method of filling valve oilers has been a glaring necessity.

For many years, at regular intervals, the engineer has wearily hunted up his operating tools and prepared to dismantle his lubricator in order to fill it. With slop bucket, monkey-wrench, waste, oil can, and often a ladder he performs the dreaded operation, for such it truly is. The writer well remembers the old Cincinnati plant of 10 engines, where he performed the operation thirty-six times each day. There was no time to do much else.



In sheer desperation he attacked the problem. The diagram shows clearly the principle of the invention, which many engineers

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will understand at a glance. But why has it not been done before?

The reservoir *a*, made of sheet copper, sets on the steam chest. There is no pressure on the reservoir, which is closed only by a loose hinged lid. A gallon or two of oil is dumped in it once or twice a week, and this is all the attention it requires. The slop bucket and ladder can be thrown away, and the waste and wrenches saved for occasions when they will be of more service.

The lubricator is filled by shutting it off as usual. The water, in running away to the sewer, pulls the oil up through the pipes *b*, *b* into the oil cup, and the whole operation is quick, clean, easy, and complete.

EDITORIAL COMMENT

THE CROSS OIL FILTER

THE Westinghouse Air Brake Company have just ordered from the Burt Manufacturing Company, of Akron, Ohio, a large Cross oil filter to equip their power house.

IMPROVED SCRAPING TOOLS

IF AN article has any utility or value it can be sold by letting people know about it. This is precisely what the Mound Tool and Scraper Co., St. Louis, Mo., wish to do when they call attention to the improved scraping tools for scraping valves, journals, bearings, etc. Packing tools and high-grade crucible steel chisels are becoming more popular every day, and the company reports increasing sales of them every month. With every sale this month they are giving the Louvine bent grooving chisel free to all readers of SCIENCE AND INDUSTRY.

VICTORIA JUBILEE BRIDGE

WE HAVE received, with the compliments of the Grand Trunk Railway System, a splendid souvenir of the Victoria Jubilee Bridge across the St. Lawrence River. This bridge was opened for traffic on December 13, 1898. The volume is beautifully printed on plate paper, illustrated by excellent photogravures, and is a complete description of the new bridge and the ceremonies attending its opening; of the old method of reaching Montreal by ferry from Longueuil in 1855; of the old tubular bridge built in 1860 and replaced by the new one; etc. The volume is a work of art in every respect, and is beautifully bound in an engraved aluminum cover. The Victoria Jubilee Bridge now in use in crossing the St. Lawrence River is one of the best pieces of modern engineering work in America, and its construction by the Grand Trunk Railway System will prove an important factor in the future development and industrial growth of the beautiful city of Montreal and the Province of Quebec.

GERM-PROOF FILTER

IN the March, 1900, issue of SCIENCE AND INDUSTRY appeared a description of a self-cleaning germ-proof filter manufactured by The Metropolitan Filter Co., 97 Washington St., Chicago, Ill. It is guaranteed to remove foreign matter from drinking water. Since that article was written we have used one of these filters every day, as steadily as a family of eight can use a filter, and we take pleasure in stating that it has furnished clear pure water without fail all that time, no matter how muddy the common water might be.

The name of this filter is "The Tyden," and we feel justified in recommending its use. Its construction is ingenious yet simple, and its operation is such that the filtering material is kept clean by the water that is run off at the kitchen sink. Write the manufacturers for their illustrated catalogue. It contains some valuable information and is worth a place in your library.

THE IMPROVED WILLIS PLANIMETER

THE most common application of the indicator to a steam engine is for the purpose of estimating the power developed; it therefore follows that any device for making the diagrams more thoroughly available for their purpose by reducing the labor involved in "working them up" is second in importance only to the indicator itself. In fact, it has come to be a generally accepted principle that in order to reach its field of greatest usefulness the indicator must be accompanied by a planimeter.

Of the recent developments in this instrument, one of the most interesting and useful is the improved Willis planimeter, made

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and sold by James L. Robertson & Sons, 197 Fulton Street, New York. The readings of this instrument are taken from a triangular scale with graduations corresponding to the scales of indicator springs. By this scale, in combination with an adjustment for setting the planimeter to the length of the card, the M. E. P. of the diagram can be read directly without the necessity of making any numerical calculations. Much time is thus saved and the danger of introducing errors is greatly reduced.

In addition to its application to finding the M. E. P. of indicator diagrams, this planimeter is especially adapted to the measurement of areas from drawings either full size or to scale. By a combination of the different scales of the instrument with certain adjustments of the tracing point, areas from scale drawings can be read directly from the instrument, in either square inches, square feet, or square yards.

BOOK NOTICES

SMALL TALK ABOUT BUSINESS. By A. E. Rice. A banker's business hints for men and women. Revised and enlarged; 128 pages; handsome cloth binding. By mail; 50 cents. Descriptive circular free. Fremont Publishing Co., Fremont, Ohio.

This book, as its name indicates, is a talk about business—a banker's talks to men and women about common every-day business affairs. It is brimful of useful ideas for both old and young, and should be on every desk and in every home.

PHYSICAL CULTURE. By B. F. Johnson; 123 pages; first edition. B. F. Johnson Publishing Co., Richmond, Va. Price, cloth, 25 cents.

This is a primary book on physical culture and hygiene intended for use in the school and home. The fault of most books on these subjects is that they are too scientific for practical use. This work is well illustrated, the directions are very simple and practical, and is just what is needed. The work is fully illustrated.

CHURCHES AND CHAPELS. By F. E. Kidder, C. E., Ph. D., architect. 157 pages of text matter, with 120 illustrations besides 52 plates of half-tone reproductions of photographs and scale drawings. Second edition; revised and greatly enlarged. William T. Comstock, New York. Price $3.00.

Mr. Kidder could hardly have used a keener and more forceful paragraph than that which he employs in one of the leading chapters of his recent work when he quotes: "The sin of unchristian building is not committed wilfully, nor with joy that so much evil be perpetrated. The error lies not so much in doing what ought not to be done as in not knowing what should be done." While the latter portion of this quotation should certainly fail to apply to the work turned from the hands of practicing architects, the fact yet remains that nowhere is poor designing so evident, both in plan and elevation, as in church architecture. Much of the trouble is undoubtedly due to influences brought to bear for no other class of buildings. Church building committees, a worthy class of men, but often entirely ignorant of design and architectural construction, usually endeavor to employ their powers of persuasion to wean the architect from his better judgment. On the other hand, the architect often fails, in his study of the subject, to consider the peculiar requirements of his denominational clients, and sometimes, in his efforts to create an imposing structure at the low cost stipulated by the church committee, produces an architectural abortion that utterly fails to substantiate the old adage that beauty is the handmaid of religion.

The book is from the worthy pen of the author of "Building Construction and Superintendence," and is a work that may well be read by even the best-informed church building committees. As a note book for the architect's library it fills a place that has been too long vacant. The suggestions for building committees given in the first chapter are calculated, if followed, to save much trouble and probably some money, while the architect may find much that is new in the chapters on details of construction, acoustics, heating and ventilation, lighting, church bells, and tower clocks.

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ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

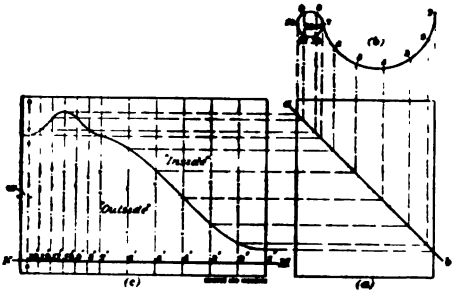
1. *Put this address both on the envelope and at the head of the letter.*
2. *Only questions of general interest to our readers will be answered.*
3. *No questions will be answered by mail.*
4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*
5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*
6. *Reference to inquiries previously answered should give date of issue and number of question.*
7. *Questions cannot be answered in the issue of the month immediately following their receipt.*
8. *Any book not out of print and for sale by regular dealers may be ordered through the magazine.*
9. *We will not undertake to calculate windings of dynamos and motors, as this involves considerable work and is seldom justified.*

MECHANICAL

(507) (*a*) How can rust be removed from connecting rods and bright work on engines? (*b*) What preparation is used to blue gun barrels, and how is it applied? (*c*) How are patterns for conductor-pipe elbows developed? (*d*) How are the patterns for eave-trough miters obtained?

H. B. S., Broomfield, W. Va.

ANS.—(*a*) Apply kerosene. This will loosen the rust somewhat and allow most of it to be scraped off. Brighten again with emery cloth. (*b*) Mix together 1 part of corrosive sublimate, 16 parts of sweet spirits of niter, and 16 parts of alcohol. The barrel having been finished with fine emery cloth, clean off all grease by rubbing with wet lime and finally with dry lime. To allow the barrel to be handled readily, wooden handles are to be driven into the muzzle and breech. Apply the mixture with a soft cloth or sponge and stand the barrel in a dry, dark place. In from 12 to 24 hours a thick coating of rust will have formed, which is removed by carding with a file card. The proper stage of rusting has been reached when the rust flies off as soon as the card is applied. Repeat again and again. After from 6 to 8 coats have been applied, the barrel will be a deep brown-black. Put it into a trough and pour boiling water over it. In a few minutes the barrel will turn blue-black. Let it cool off slowly and oil when cool. (*c*) The method of obtaining elbow patterns is described in the April, 1899, issue of "The Mechanic Arts Magazine," in Answers to Inquiries, No. 85. (*d*) Draw a plan and an elevation of the eave trough as shown, respectively, at (*a*) and (*b*) in the figure. Across the plan draw the required miter line *a b*, the angle of which is determined by bisecting the angle made by the eave-trough miter. Next, locate a number of points on the outline of the eave trough in the elevation, as shown at (*b*) by the points numbered *1, 2, 3, 4*, etc. Note here that on portions of the outline where the curvature is greater, the points should be closer together. Now draw projectors to the plan from the points *1, 2, 3, 4*, etc., and extend them until they intersect the miter line *a b*. The stretchout *M N* is next drawn at right



angles to the projectors, as shown at (*c*). On this line points *1', 2', 3', 4'*, etc. are laid off with the dividers at distances similar to those in the elevation at (*b*). Draw perpendiculars to *M N* through *1', 2', 3', 4'*, etc. at (*c*), and finally parallels to *M N* from the points of intersection on the miter line. The irregular outline of the pattern may then be traced through the drawing at (*c*), as shown in the illustration. That portion of the pattern below the irregular curve may be used for the pattern of an outside miter, and the remainder of the development for an inside miter. The space *w* is added to the pattern to provide a tongue for insertion in the beader rod.

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(508) (*a*) What is the principle of the hydrocarbon oil burner? (*b*) Can you recommend a good book on metallurgy? H. A. M., New Orleans, La.

ANS.—(*a*) Hydrocarbon oil burners, generally speaking, are composed of a burner proper that easily takes in a supply of fresh air, and a heating pipe that is so arranged in or near the flame that it heats and vaporizes the oil before it reaches the burner. This converts the oil into gas, which, when ignited, should burn with a fairly steady flame. (*b*) For a general introduction to the subject we would suggest "An Introduction to the Study of Metallurgy," by W. C. Roberts-Austin, price $4.00; or "Elements of Metallurgy," by J. A. Phillips, price $9.00. Either may be obtained from The Technical Supply Co., Scranton, Pa.

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(509) (*a*) Please give a formula for calculating the diameters of the steps of cone pulleys; for example, if we have two cone pulleys with three steps each, to be placed 24 inches from center to center, the diameters of the three steps of the one pulley being 7½", 5", and 3½", respectively, while the middle step of the other pulley is 10 inches in diameter, how may the diameters of the other two steps on the second pulley be calculated? (*b*) Explain what is a 7½" × 12" engine. W. S. G., St. Louis, Mo.

ANS.—We do not know of a simple and reasonably accurate mathematical formula for calculating the dimensions of the required steps. There are several graphical methods of solving the problem, all of which would require more space than we can spare here. A very satisfactory method of solution is the

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tabular method to be found in Klein's "Elements of Machine Design." By this method the diameters of the required steps are calculated from simple formulas in conjunction with tables of values that correspond with the range of conditions usually found in practice. The price of the book is $6.00, and it may be obtained from The Technical Supply Co., Scranton, Pa. (*b*) By the expression "a 7½" × 12" engine" is meant an engine having a cylinder diameter of 7½ inches and a stroke of 12 inches.

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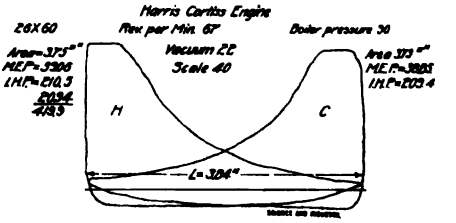
(510) Please point out the defects of the accompanying indicator diagrams and explain how to remedy them; also calculate the horsepower. The diagrams were taken from a 26 × 60 Harris-Corliss engine, running 67 revolutions per minute. Boiler pressure, 90 pounds; vacuum gauge, 22 inches; scale of indicator spring, 40. H.W., May's Landing, N.J.

ANS.—The most prominent defects are the late admission of the crank end and late release of both ends. Compression might also be increased, with a probable improvement in the operation of the engine; this, however, can best be determined by observing the action of the engine; if it runs quietly with compression increased, the change would be beneficial.



These defects can probably best be remedied by increasing the angle of advance in the eccentric so as to give the exhaust valves and the crank-end steam valve more head, then adjust the head-end steam valve rod so as to keep its lead about the same as at present. Measured with a planimeter, the mean effective pressure of the head and crank ends are found to be, respectively, 39.06 and 38.85 pounds per square inch; under the conditions named, this corresponds to a total indicated horsepower of nearly 420.

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(511) In the article "Furnaces and Firing," in your October number, you speak of the "coking system" of firing. (*a*) What is this system, and how is it accomplished? (*b*) What causes the fire in a locomotive firebox to burn more at the front end than at the back? J. P., Antigo, Wis.

ANS.—(*a*) The coking system of firing consists in putting the fresh fuel on the front part of the grate (i. e., just inside the door), and letting it stay there until the gases have been distilled off; in other words, until the coal has been converted into *coke*. It is then pushed along and spread out over the back part of the grate, and more fresh fuel added in its place. By doing this, the gases that arise from the new charge have to pass over a considerable extent of incandescent fuel, and are thus more thoroughly consumed than they could otherwise be. The same method can also be employed in locomotive work, the fuel being put on the "back" part of the grate (as the part next the door is termed in locomotive parlance); and then when coked—i. e., deprived of its volatile matter—it is pushed forward and spread out as before. The gases that arise from the new fuel mix with the air coming in through the door, thus forming the combination necessary for combustion. When, instead of doing as above, the fresh coal is distributed all over the grate, the gases arising from the coal near the tube sheet pass out of the tubes immediately, and thus cause a waste of heating power. Of course, where a brick arch is used, the case is different, for all the gases arising from the coal at the front end of the box—i. e., against tube sheet—have to come back toward the door and then return along the top of the arch before reaching the tubes, and this arch, being maintained at a very high temperature, aids materially in bringing about a complete combustion of the gases. (*b*) The steam escaping from the exhaust nozzle creates a partial vacuum in the smokebox, causing a rush of air and gases through the tubes. To supply their place, air comes in through the grates—supposing the fire-door to be tight shut; that coming in through the front part of the grate naturally passes up through the lower tubes, which are the first place of exit encountered, and that coming through the back part goes up and along the length of the box and so into the upper tubes; air coming through the middle portion of the grate goes into the middle rows of tubes. In each case we suppose all the tubes to be clear, of course. Now, if the exhaust nozzle is set high up in the smokebox, it will create the strongest draft through the upper tubes; if low down, through the lower tubes. The result in the two cases is a stronger draft through the back and front parts of grate, respectively. A draft appliance, however, is always provided, by which the pull of the "blast" may be more or less equalized throughout the various rows of tubes. This appliance is either in the form of a deflector plate or else a petticoat pipe. If a deflector (called also a diaphragm or draft sheet) is in use, and the fire is found to burn most at the back end (i. e., under the door), it shows that the deflector has been dropped too low, thereby choking off the draft through the upper tubes and causing the fire to burn dull at the place mentioned. If a petticoat is the appliance in use, a dull fire under the door is a sign that the pipe is too high, thus cramping the outlet for the escaping gases between the top of the exhaust pipe and the base of the stack.

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(512) I have a battery of two horizontal tubular boilers with the steam main and feed-pipe connected up in the following manner: From a steam dome on each boiler a branch pipe is run to the main, the branch from the first boiler joining the main line by means of an L and that from the second by a T. Each branch is provided with a stop-valve and, in addition, there is a stop-valve in the main near the connection of the second branch. There is a reducing valve in the main just beyond the main stop-valve. The main feed-pipe connects to each boiler through a branch that enters the blow-off pipe, the latter being connected to the lower side of the shell at the rear end, in the usual manner. Each branch of the feed is provided with a stop-valve but no check-valve. The main is provided with a check-valve near the cross-fitting by means of which it is connected to the two branches, and this is the only check between the pump and the two boilers. I have run this plant for the last two years and it has given me no trouble. I think it is better to have only the check on the main feed pipe and no check on the branches, since by this arrangement it is not necessary to watch the water level in both boilers. Please give me your opinion of this arrangement of piping. R. K., Missoula, Montana.

ANS.—From your description the arrangement of the steam piping is satisfactory. For the feed piping, however, we would strongly advise the use of a check-valve in addition to the stop-valve on the branch to each boiler. Place the stop-valve next to the boiler, so that the check can be examined or repaired without emptying the boiler. With the arrangement you now have, if the stop-valve in one of the branch pipes should accidently be left closed, or if one of the branches should become clogged and

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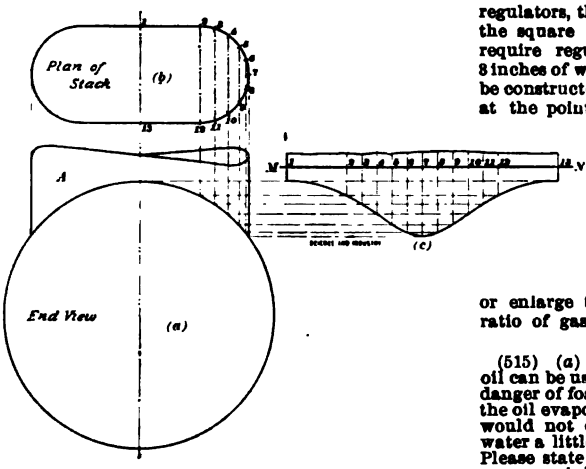
you were depending wholly on the water gauge of the other boiler to determine the water level for the two boilers, the water in the boiler having the clogged pipe would get low and result either in an explosion or the ruin of the boiler. In any battery of boilers, no matter how many there are in the battery, the feed branch to each boiler should have its own stop- and check-valves, and the water level should be regulated for each boiler by itself. Instead of connecting the feed pipes to the blow-off, we would prefer to introduce the feedwater into the boiler through the front head a short distance below the water level, and carry the feed pipe back horizontally to a point about one-third of the length of the boiler from the back head.

***

(513) Will you please show me how to make the layout on the flat sheet of the intersecting smoke connection *A* on the accompanying drawing?

F. J. H., Silver Cliff, Colo.

ANS.—The sketch referred to by the correspondent is reproduced at (*a*) and (*b*), an end view and a



plan, respectively, of the desired connection. Draw the vertical center line through the projection drawings, in order that symmetrical halves may first be designated. Next, locate a number of points at regular intervals on the curved portion of the edge view of the stack, as *2*, *3*, *4*, . . . *18*, and fix other points on the same profile at the intersections of the center line. The stretchout *M N* is then drawn in the position shown at (*c*), and points *1* to *18* set off thereon with dividers. Through these points perpendiculars to *M N* are next drawn in view at (*c*), and corresponding projectors are also drawn between the two views (*a*) and (*b*). From the lower intersections in the view at (*a*) parallels to *M N* are finally drawn to (*c*), when the irregularly curved outline of the layout is next defined as shown in the illustration. The pattern for the opening in the smokebox is not shown, since a similar process applied to the upper view (*b*) will give the required pattern.

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(514) (*a*) Makers of sprinkling acetylene-gas generators claim that carbide dropped into large quantities of water loses at least 20 per cent. of the gas. On the other hand, makers of plunge or drop machines claim that sprinkling makes an undesirable quality of gas. Which is right, if either? (*b*) I have a frame of cast iron weighing 80 pounds. How can I coat this frame with block tin? (*c*) What effect does salt water have on aluminum phosphor bronze, plain bronze, bronze mixed with nickel, and nickel mixed with cast iron? (*d*) What is the greatest pressure of acetylene that the underwriters will allow? (*e*) Can air be safely pumped in with acetylene gas and used for a tinner's torch flame? (*f*) Can acetylene gas be used for driving a gas engine? If so, what are the requirements needed, and what would be the cost compared with the city gas? (*g*) If acetylene is stored for 30 or 60 days will it condense: if so, how much? (*h*) Describe a burner for acetylene gas that I can use for melting one pound of Babbitt metal. G. H. K., Cleveland, Ohio.

ANS.—(*a*) Both, to a certain extent, are correct; but the percentage depends considerably on the volume of water into which the carbide drops; and the impurity of the gas by the sprinkling process depends considerably on the style of machine and how the gas is taken from the generator. (*b*) Thoroughly clean the iron by pickling in a dilute sulphuric acid (1 to 20 of water) scouring with sand, if necessary. Then boil the iron in a concentrated solution of stannate of soda, with a quantity of granulated tin. (*c*) These alloys are not affected by salt water. (*d*) For apparatus requiring pressure regulators, the gas pressure must not exceed 3 lb. to the square inch; but for apparatus that do not require regulators, the pressure must not exceed 3 inches of water column. (*e*) No; the burner should be constructed to take its air from the atmosphere, at the point where the gas is consumed. If air and gas are mixed together in the chamber, there is liability of explosion. (*f*) Send for The Acetylene Motor Number of the "Horseless Age," published June 20, 1900, by E. P. Ingersoll, Nassau and Spruce Streets, New York. Price, 10 cents. (*g*) No. (*h*) Use a common Bunsen burner, and restrict the gas aperture or enlarge the air holes until you get the proper ratio of gas and air.

***

(515) (*a*) Please inform me about how much coal oil can be used in a boiler of 30 horsepower without danger of foaming. I am under the impression that the oil evaporates soon after entering the boiler and would not cause foaming if pumped in with the water a little at a time, say 7 or 8 times a day. (*b*) Please state whether zinc will cause foaming or in any way injure a boiler if used to any extent to prevent corrosion. G. A. B., San Bernardino, Cal.

ANS.—(*a*) Just how much oil will cause foaming is a matter of experiment. Reasoning from experience, we think that you may use as much as a pint a day without any danger. Instead of introducing it at stated intervals, it is considered better to feed it steadily throughout the day. Special lubricators for this are in the market. (*b*) We have never heard of zinc causing foaming, and cannot imagine any conditions under which foaming could be induced by it. Neither have we heard of any case where zinc has proved injurious to the boiler.

***

(516) (*a*) What kind of steel are railroad rails made of? (*b*) How are they reworked after they have been worn out? (*c*) Please explain how large pieces of wrought and steel scrap are reworked. (*d*) I notice that most railroad iron forges badly and will not weld; is it purposely made that way, or is it a low grade of steel? (*e*) Can glass be poured into molds in the same manner as lead and similar materials, and so be cast into any desired form?

S. T., Houston, Texas.

ANS.—(*a*) Railroad rails are made from a special grade of steel that is usually made by the Bessemer process. The steel is purposely given a comparatively high percentage of such hardening elements as carbon and manganese, so that the rails will be hard enough to wear well. On account of the high percentage of these elements the steel does not work readily

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in the forge, and can be welded only with the greatest difficulty. (*b*) The usual method of reworking old rails is to remelt them together with the other materials from which new steel is being made. In some cases large sizes of old rails have been reheated and rolled down into smaller sizes. (*c*) The most common method of reworking large pieces of either wrought or steel scrap is to remelt them in combination with other materials that are used in the manufacture of new steel. (*d*) See answer to (*a*). (*e*) Glass can be poured into molds and so be cast into various forms, but, on account of its viscosity or the difficulty of making it fluid enough so that it will run freely, it cannot be made to fill delicate patterns in a mold as readily as most metals.

***

(517) (*a*) What is meant when speaking of an eighteen or twenty gauge saw? Does it mean that the saw is the eighteenth or twentieth part of an inch thick? (*b*) Can you give me a recipe for a belt dressing to prevent a belt from slipping? (*c*) Can you give me a system of putting a tightener on a mule? (*d*) Do you know of any way of making a bushing for a mule that will not heat? We use the ordinary plain straight bushings at present. (*e*) Does it make any difference, as far as good working of a mule is concerned, whether the pulleys are not the same diameter? In this case they are 36 and 80 inches in diameter for an 18 by 12 mule.

R. W. D., Montreal, Can.

ANS.—(*a*) It means that the thickness of the saw is such as to just fit a slot marked number 18 in an arbitrarily selected gauge that has been commonly adopted by the trade. (*b*) The best belt dressing we know of is castor oil. (*c*, *d*, and *e*) Since we are not familiar with the machine you mention, we cannot advise you intelligently.

***

(518) Suppose that the engine, when working full speed ahead, will drive a steamer through still water at the rate of 10 miles an hour. Now, let this steamer be steaming up a river against a current running at the rate of 4 miles an hour, the water being fresh in both cases. Will the steamer move through the water at the same speed in the current that it does in still water?

S. W., Montreal, Quebec, Can.

ANS.—The steamer will move through the water at the same speed in both cases. This does not mean, however, by any means, that its progress up the river against a current will be as fast as in still water. When it advances 10 miles in one hour in still water, it will, when steaming against a 4-mile current, advance 10 — 4 = 6 miles in one hour, and when going with the current, advance 10 + 4 = 14 miles in one hour.

***

(519) Can you suggest any material suitable for making a tube that will withstand the action of slightly acid copper water? Phosphor bronze has been suggested. Can tubes be made from this alloy?

E, Butte, Mont.

ANS.—A compound that has been found very successful at Butte for the water ends of mine pumps and for column pipes, etc., is composed of 84.77% of copper, 14 91% of tin, and .32 of antimony. The Eynon-Evans Manufacturing Co., of Philadelphia, manufacture an acid-resisting compound for casting purposes with a composition similar to the above, but neither of these can be drawn into tubes. Phosphor bronze would not be suitable for condenser tubes if the water were highly acid, though it probably would be better than almost any other compound. We think tubes made of solid block tin would be the most satisfactory for this use, as tin is unaffected by almost all acids. The greatest objection to tin is the fact that the metal is rather soft, and the tubes would therefore be liable to sag.

***

(520) What is the Barff process that is used in England to produce "rustless" iron? The preparation that is applied will wear for some time, and differs from "anti-rust" inasmuch as it cannot be rubbed off. Can you tell me where it can be procured, and whether or not it is worked in with the iron?

W. P. T., Warren, R. I.

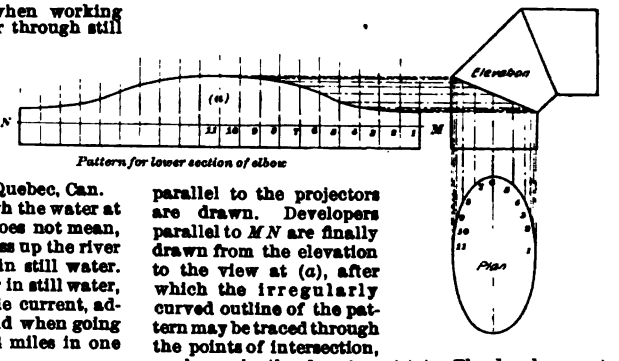
ANS.—The Barff process of artificially coating the iron with a film of magnetic oxide is a patented one and, we have understood, is conducted as follows: The iron is heated to redness and then has steam passed over it. The iron decomposes the steam and sets free the oxygen, which forthwith attacks the metal, forming on its surface a film of magnetic or black oxide; this coating preserves the iron thereafter against moisture, etc.

***

(521) What is the method of developing patterns for elliptical elbows of any given size?

E. E. McF., Steubenville, Ohio.

ANS.—Since our correspondent gives no further specifications or particulars than as above noted, we have assumed, for purpose of exemplification, a three-pieced elliptical elbow turned in the direction of its minor axis. The plan and the elevation are first drawn as in the accompanying sketch. The outline of the ellipse in the plan is next divided by spacing into any convenient number of equal parts, and from each of the points thus located projectors are drawn to the elevation in the manner shown. Next, a stretchout for the pattern is laid off along the line *M N* in (*a*) at right angles to the projectors, and through each point of division thereon lines



Pattern for lower section of elbow

parallel to the projectors are drawn. Developers parallel to *M N* are finally drawn from the elevation to the view at (*a*), after which the irregularly curved outline of the pattern may be traced through the points of intersection, as shown in the drawing at (*a*). The development of the necessary patterns is thus shown to be accomplished in a manner closely resembling that used for the ordinary elbow in round pipe. For a more extended description of the process, the correspondent is referred to the answer to question No. 85, in the April, 1899, issue of "The Mechanic Arts Magazine."

***

(522) (*a*) In a high-duty pumping engine in fairly good condition, what percentage of the plunger displacement is discharged per stroke? (*b*) Does the percentage of discharge vary with the speed of the engine? (*c*) What is the most efficient piston speed for ordinary conditions?

W. K., Great Falls, Mont.

ANS.—(*a*) From 90 to 95 per cent. (*b*) If the speed does not vary too much from standard running conditions the percentage of discharge should not vary to any great extent. (*c*) The most efficient piston

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speed depends on the size and design of the pump and the proportions of suction and discharge pipes. In general, it may be said that the piston speed should be as high as possible without producing water-hammer. For ordinary conditions, the limit is generally placed at 100 feet per minute, but this is sometimes exceeded and a speed as high as 250 feet per minute has been attained with satisfactory results.

***

(523) In making alterations in my plant, would it be of any advantage to use the gases from the chimney to supply to the boiler furnace as draft? In other words, would it do to connect the suction end of the fan that supplies draft for the furnace to the chimney? W. R. H., Philadelphia, Pa.

ANS.—It would be a most decided disadvantage to draw the gases from the chimney and blow them into the furnace. A satisfactory statement of the reasons for this would take more space than can be spared in these columns; we think, however, that a study of some of the articles on firing and the combustion of fuels that have appeared in different issues of this magazine will help you to understand this subject.

ELECTRICAL

(524) I would like to know of a good book for instructing a man running an electric mine locomotive, in the principles and care of the machine. The book should be suitable for one of poor education and practically no technical knowledge.

F. R. R., Nuttallburg, W. Va.

ANS.—We do not know of any book of the kind you mention that relates specially to mining locomotives, but you will find a great deal of useful information in Crocker and Wheeler's "Practical Management of Dynamos and Motors," price $1.50, which gives general directions for the handling of electrical machinery. "The Motorman's Guide," by Gayetty, price 75 cents, gives information relating to railway motors and controllers. Either of the above works may be obtained from The Technical Supply Co., Scranton, Pa.

***

(525) Please be kind enough to furnish me with the following desired information on lightning protection. (*a*) Can a No. 0 B. & S. copper wire be used as a lightning rod? (*b*) How should it be grounded? (*c*) What should the points be made of? (*d*) Where can good points be bought? W. E. W., Salem, Va.

ANS.—(*a*) Yes; No. 0 copper will make a very good rod, but No. 0 stranded copper cable would be preferable, as it is much easier to put up. (*b*) Dig a hole about 4 feet square, and dig it deep enough to be sure that the earth will always be moist at the bottom. Lay a layer of coke or charcoal about 4 inches thick on the bottom, and on the top of this place a copper plate about 3 feet square. Solder the rod or cable across the whole width of the plate and place on top a 6-inch layer of coke or charcoal, using water to settle; then fill up the remainder of the hole with earth. Run your lightning rod as straight as possible, and make only such turns or bends as are absolutely necessary. (*c*) The points are usually made of copper. A straight copper rod drawn down to a point answers well. Sometimes the points are plated, to prevent corrosion; this is desirable but not absolutely necessary. (*d*) You can obtain this material from E. G. Washburne & Co., 46 Cortlandt St., New York City.

(526) (*a*) Kindly tell me where I can obtain a book entitled "The Electric Automobile," by C. E. Woods. (*b*) Can a storage battery be used to run a ½-horsepower motor, and what would the expense be?

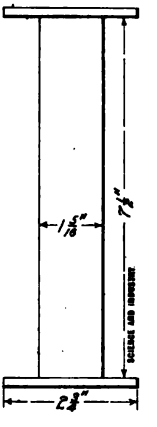
A. J. M., Arbutus, W. Va.

ANS.—(*a*) You can obtain this book from The Technical Supply Co., Scranton, Pa., price $1.25. (*b*) Yes; a direct-current motor may be easily operated by means of a storage battery. The first cost of the battery will depend upon its capacity, and this in turn will depend upon the length of time you wish it to run the motor without recharging. The cost of operation will, of course, depend largely upon what you have to pay for the charging current. As you have given no data regarding either of the above items, it is impossible for us to give any figures as to the cost and operating expense. The Electric Storage Battery Co., Philadelphia; or Sipe & Sigler, Cleveland, Ohio, could inform you as to the cost of a battery, if you give them full information regarding the capacity required.

***

(527) I have a solenoid core and spool of a magnetic brake that I wish to wind with No. 12 B. & S. double cotton-covered wire. Kindly figure out the number of feet required to wind the spool shown in the accompanying sketch, or give a formula for obtaining the length.

P. A., Hoboken, N. J.



ANS.—We will allow $\frac{1}{16}$" insulation on the core and ¼" at each end. The length of the winding space will then be $7\frac{1}{8} - \frac{1}{2} = 7\frac{1}{4}$". The depth of the winding space will be $\frac{1}{2}\left\{2\frac{1}{8} - (1\frac{5}{16} + \frac{1}{2})\right\} = \frac{5}{16}$" = .656". No. 12 double cotton-covered wire will have an outside diameter of about .095", hence the number of turns per layer will be $\frac{7.25}{.095} = 76$, nearly. The number of layers will be $\frac{.656}{.095} = 7$, nearly. The total number of turns will then be $76 \times 7 = 532$. The inside diameter of the winding will be $1\frac{5}{16} + \frac{1}{2} = 1\frac{13}{16}$". The outside diameter is $2\frac{1}{8}$", hence the average diameter of a turn is $\frac{1}{2}(1\frac{13}{16} + 2\frac{1}{8}) = 2\frac{5}{16}$". The average length of a turn in feet will then be $\frac{3.1416 \times 67}{32 \times 12}$, and the total number of feet required to wind the spool will be $\frac{3.1416 \times 67 \times 532}{32 \times 12} = 291.6$. As the thickness of the insulation on the wire may vary somewhat, it will be well to figure on at least 300 feet. The diameter of the double cotton-covered wire may, for example, be as low as .091" instead of .095" taken above.

***

(528) (*a*) Can a spark coil give a current for medical use, the same as an induction coil? Please give any changes that have to or can be made. (*b*) Can battery incandescent lamps be lighted by simply attaching them to the wires from the batteries?

W. E. K., Detroit, Mich.

ANS.—(*a*) You do not state what kind of spark coil this is, whether a jump-spark coil with a vibrator, or a simple spark coil consisting of a single coil of wire wound on an iron core. If it is the former kind, it can be used as a medical coil, though it might be rather powerful for this purpose. If it is too strong, you can put a resistance in the primary circuit or remove some of the turns from the secondary. A medical coil should be provided with a well made vibrator. If the coil consists of a single

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coil of wire wound on an iron core, it is not of much use as a medical coil. You could get an induced current from it by providing it with an interrupter in series with the coil and the battery, and connecting the electrodes across the terminals of the coil. For satisfactory work, however, there should be two coils, a primary connected to the battery through a vibrator, and a secondary wound over the primary and connected to the electrodes. (*b*) Yes, if the battery gives just the voltage for which the lamp is designed. If the voltage of the battery is higher than that of the lamp, you must insert a resistance in series, otherwise the lamp will be burnt out.

***

(529) I have a motor-dynamo set that I have tried to run. It consists of one Towle fan motor (2-ft. blades) dismantled, with 9½" × 1¼" pulley. It is series connected and runs on a 110-volt lighting circuit; it has 4 field coils of about 720 turns each, No. 24; the armature is 4½ inches in diameter and has a 2½-inch face, 12 slots, No. 28 wire. This machine drives an Eldridge electroplating dynamo, rated at 6 volts, 12 amperes, speed 2,200. This machine has one field coil of coarse wire. The armature, 2½ inches in diameter and 4-inch face, is driven by a 2½-inch pulley. The above motor will give a dynamo output of but 2 volts and 6 amperes. Connected in shunt, it does a little better, but the fields heat almost instantly. Can you suggest a field winding that would give the required power and speed, or make any other suggestion that will help matters?

G. E. M., Cumberland, Md.

ANS.—The trouble is no doubt due to the motor not having power enough. According to the figures you give, the motor must be running about 520 rev. per min.—a very low speed for a machine of this size. These ceiling-fan motors are wound for such a low speed that they are not efficient and are incapable of developing much power. Your best plan will be to rewind the armature with a larger wire and put on less turns. If you use No. 24 instead of the No. 28 now on the motor, you will get on about one-third as many turns and your motor will run about three times as fast, thus giving you a great deal more power. If you wish to run the machine as a series motor it will be sufficient to change the field by connecting the coils in pairs and putting these two pairs in parallel. Since the motor will, when rewound, develop more power, it will take more current from the line, and hence the fields must be connected in parallel pairs in order to provide the necessary carrying capacity. The speeding up of the motor will cause it to take more current, so that it will be necessary to connect the fields in parallel pairs in order to carry the current. A series motor is not satisfactory, however, for this work, as it is apt to race when the load is thrown off and give a variable speed with changes in load. You would need to rewind the fields with at least No. 30 or 32 to allow them to be operated in shunt. Perhaps the easiest plan would be to simply rewind the armature and leave the fields as they are, but separately excite them from the mains and put enough resistance in series with them, say two or three lamps in parallel, to keep them from heating. This is not the most economical way, but the waste would not be very great. It would save the expense of rewinding the fields and at the same time give the advantage (constant speed) of a shunt motor.

***

(530) Kindly inform me how to make an induction coil for the ignition of a gasoline engine (jump-spark method). It is for a motor cycle, and I wish it to be as small as possible and give a good spark with three cells of dry battery.

R. D. M., Northampton, Mass.

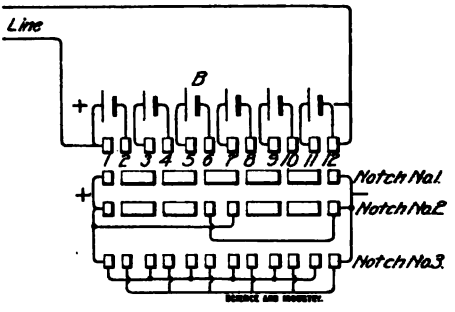
ANS.—See November, 1900, issue, Answers to Inquiries, No. 483. The coil there described has proved satisfactory, and while a coil might be made smaller, you will make a mistake by trying to cut down on your battery power and the size of the coil. The most frequent cause of failures in the ignition apparatus is the use of too small a battery and coil. We would therefore recommend you to use the coil and battery as described unless you are prepared to renew the cells frequently and run the risk of them giving out when they are most needed.

***

(531) I have a battery of 75 cells. Can a switch be made so that they may be thrown either in series or in multiple connection, without reconnecting the cells?

G. W. B., Three Rivers, Mich.

ANS.—A controller switch may be made for this purpose. There would be, however, so many connections for a 75-cell battery that the controller



would be very expensive and of large size. The accompanying sketch illustrates a controller switch arranged for 6 cells. *B* represents the battery. The terminals of the cells are connected to contact fingers *1* to *12*. The fingers make contact with metal strips mounted on and insulated from the metal part of the drum. When the drum is turned to the first notch, the first row of metal strips comes in contact with the fingers and the cells are then connected in series; when the controller is moved to notch No. 2, the cells are connected in multiple series—that is, two groups, each of three cells in series, are connected in multiple; when the controller is on notch No. 3 all the cells are connected in multiple. The same general plan of connections could be used for a controller to operate a 75-cell battery.

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(532) I have a ¼-horsepower Baxter motor which I am running as a generator. The voltage of the machine is so low that it is impossible to light a 50-volt lamp. The armature contains 32 sections, 4 wires in width, of No. 18 wire; the field is wound with wire as per sample. (*a*) Will you kindly inform me as to how I can raise the voltage to about 60, and if possible to do so without damaging the windings of the armature? (*b*) Also please give me the address of the Baxter Electric Motor Co.

U. S. S., So. Weymouth, Mass.

ANS.—(*a*) The sample of field wire submitted shows that the machine is series wound. It was probably intended originally to operate on a 10-ampere arc circuit, and hence when run as a dynamo would not generate more than 30 to 35 volts. Since this is a series machine, you must have the external resistance low enough to allow sufficient current to flow to excite its fields fully. It would not come up to voltage on a 50-volt lamp, and you would need several such lamps in multiple to allow the full load current to flow. To increase the voltage without rewinding the machine, you must drive it at a higher speed. A series-wound dynamo would, however

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never be satisfactory for operating incandescent lamps. As soon as you turned out lamps, the current would decrease and the voltage would come down. If you wish to run the machine as a series dynamo, the best plan is to use lower-voltage lamps instead of driving at a higher speed, as the speed is no doubt already as high as is safe. (*b*) We have been unable to find the address of this firm, and have the impression that it is not now in existence under this name.

***

(533) (*a*) Please give the relative conductivity of platinum as compared with copper. (*b*) What size platinum wire is necessary to carry 10 amperes a distance of 8 inches at a pressure of 6 volts? Also what size platinum wire is necessary to carry 2 amperes the same distance at the same pressure?

F. McD., Johnsonburg, Pa.

ANS.—(*a*) Taking the conductivity of annealed copper as 100, that of annealed platinum is 17, i. e., platinum has about 5.88 times the resistance of copper. (*b*) A No. 31 wire would carry the current, so far as giving the drop is concerned, but such a fine platinum wire would not carry 10 amperes without burning out. If you wish to carry 10 amperes and use a pressure of 6 volts, you must use a longer length of larger wire. It would require a No. 38 wire to give a drop of 6 volts through a length of 8 inches, and such a fine wire would not stand 2 amperes. If you must keep the length the same, it would be better to use a lower voltage. Ten amperes would heat a No. 16 or 18 wire to a bright heat.

***

(534) (*a*) Will you please inform me what platinum sponge is and where it can be procured? (*b*) What is the strongest and lightest solution battery made? I want to connect up a spark coil and I want as large a spark and as small a battery as possible for motor igniters. B. C., Cadiz, Ohio.

ANS.—(*a*) Platinum sponge is metallic platinum in a finely divided or porous state. It may be made by heating ammonium-platino-chloride. Its most striking property is its capability of absorbing about 800 times its own weight of oxygen. You can probably obtain it from Eimer & Amend, New York. (*b*) The Edison-Lalande or Gordon cells have as large an output for their weight as any primary cells we know of. They are well adapted for motor igniters. Dry cells are not so satisfactory for this work, as they run down more rapidly. There is little choice, as regards weight, between the different makes of dry battery.

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(535) (*a*) In a compound-wound alternator of the Wood or General Electric type, where the machine is compounded by leading the main armature current (with the exception of that which passes through the stationary shunt) through the series field coils, what is the approximate voltage measured across the commutator from brush to brush? (*b*) What is the voltage on the later type of machines, where a converter is used to supply the series field?

F. M. VAND., Omaha, Neb.

ANS.—(*a*) The value of this voltage depends on the size and general design of the machine. It is, however, always comparatively low—in the neighborhood of 8 or 10 volts at full load for a 120 K. W. G. E. dynamo—because all that it represents is the drop in voltage through the series field. If you know the resistance of the series field and the current flowing through the field coils, you can obtain the voltage across the brushes by multiplying the two together. (*b*) The voltage in this case is also low; in fact, one of the advantages of the transformer is that it avoids connecting the field windings to the armature, in which a high pressure is generated. The exact voltage generated may vary widely in different machines, depending on the number of secondary turns used; it is, however, kept as low as possible without interfering with the design in other respects.

***

(536) Will you kindly give directions for constructing a watch demagnetizer for use on alternating current? F. R., Sea Cliff, L. I.

ANS.—You may make one form of demagnetizer as follow Turn up a hardwood spool about 2½" inside diameter by 3½" outside. This spool should be about 2½" long along its axis, and be provided with ends about ¼" thick. Wind the spool full of No. 18 B. & S. double cotton-covered magnet wire and mount it on a board with its axis horizontal. If the coil is to be used on an ordinary lighting circuit, connect a 32-candlepower lamp in serie with it, so as to limit the current. Place the watch in the coil after the current has been turned on, and while the current is still flowing gradually draw it out along the axis and away from the coil. Repeating this process two or three times will usually demagnetize the watch. If it does not do so, connect another 32-candlepower lamp in parallel with the first one, so as to allow more current to pass through the coil.

***

(537) I have a dynamo I wish to use for igniting a gasoline engine; it has 16 slots in the armature, ½" deep by ½" wide. The commutator has 16 segments, and the laminated armature core is 4" in diameter by 4½" long. The armature runs within $\frac{1}{16}$" of the poles. The field is of cast iron and is wound with 4 pounds of No. 16 D. C. C. wire. What I would like to know is the number of turns and size of wire to put on the armature. I would also like directions for connecting the machine up. I do not wish to rewind the field if it can be avoided. The machine is series wound. N. G. B., Muscatine, Iowa.

ANS.—Wind the armature with No. 18 D. C. C. wire; allowing $\frac{1}{16}$" on each side of the slot for insulation will admit of 8 turns per layer. Each coil will consist of 4 layers, or 32 turns in all. Each side of a coil will fill half a slot, so that there will be 64 wires per slot, the coils being arranged in two layers. The upper and lower layers of coils should be separated by $\frac{1}{16}$" insulation. To connect the armature, attach the beginning of coil No. 1 to commutator bar No. 1 and the end of the same coil to bar No. 2. The beginning of coil No. 2 will connect to bar No. 2, and the end of the same coil to bar No. 3, and so on. All that is necessary to connect the machine up is to attach one brush to one terminal of the field. The other field terminal and the other brush will be the terminals of the machine. First see that the fields have some residual magnetism, then run the machine up to speed and see whether it will generate through a fairly low resistance. If it fails to generate, the probabilities are that the field and armature are not connected so as to allow the machine to build up. This may be remedied by reversing the field connection.

BUILDING TRADES

(538) I would like to know the best way to remove sticky varnish from church pews, and also what is a good varnish that will not have this objectionable feature. L. H. C., Madison, Iowa.

ANS.—There is a paint and vanish remover manufactured by the Seips Paint Co., Pittsburg, Pa., which comes in liquid form and is applied with a brush.

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After a coating has been applied for a few minutes the varnish or paint, as the case may be, can be readily removed with a steel blade or pallet knife. After the objectionable coating has been removed the surface should be carefully wiped with turpentine. When the wood has dried, a coating of good body varnish, such as Crocket's No. 1, can be applied in the usual manner, and we can state that this varnish will give entire satisfaction when applied as it comes from the original package.

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(539) Please inform me as to the correct method of laying out the corner ribs for the elevator cage

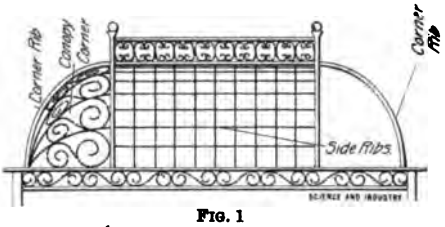

FIG. 1

canopy shown in Fig. 1. I want to determine the correct profile of the hip rib.

O. H. P., Wilmington, N. C.

ANS.—Draw first the plan and partial elevation shown in Fig. 2. Divide the outline of the curve shown in the elevation—which in this case is a quarter circle—into any convenient number of equal parts, thus locating the points *1*, *2*, *3*, *4*, etc. From each of these points draw a projector to the miter line of the canopy in the plan, and at the points of intersection on such miter line erect perpendiculars thereto in the manner shown in the illustration. These perpendiculars should be extended an indefinite distance from the plan, and *a b*—a parallel to the miter line—drawn where convenient. The vertical height of each point on the curve in the elevation must now be set off in the view at (*a*); that is, make *1′ c′* at (*a*) equal to *1 c* in the elevation, *2′ d′*

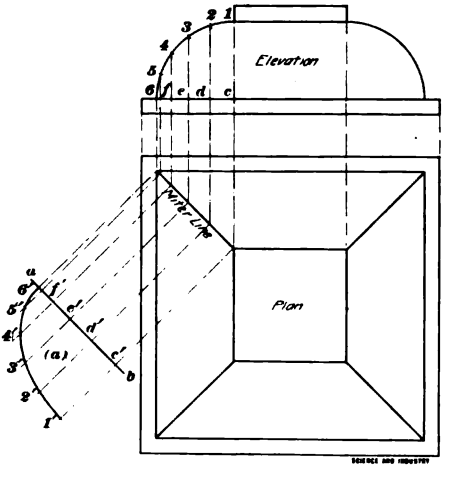

FIG. 2

equal to *2 d*, *3′ e′* equal to *3 e*, etc. The curve traced through points thus located in the view at (*a*) will define the true profile for the corner ribs of the canopy top.

(540) (*a*) Give the weight per square foot of roof surface of the following materials when used for roof covering: corrugated iron; slate; tiles; zinc; boarding, ¾-inch thick; boarding, 1¼-inches thick; gravel. (*b*) What is the pressure of wind and snow per sq. ft. on a roof? (*c*) Is Du Bois' book on roof and bridge construction considered one of the best of its kind, and what is its price?

W. S. G., St. Louis, Mo.

ANS.—(*a*) Corrugated iron, No. 26 to No. 18, 1 to 3 pounds; slate, 1/8 to ¼ inch in thickness, 7 to 9 pounds; flat tiles, 15 to 20 pounds; Spanish tiles, 8 to 10 pounds; zinc, 16 oz., 1 pound; spruce or hemlock boarding, ¾ in. in thickness, 2 pounds; spruce or hemlock boarding, 1¼ inches in thickness, 4 pounds; gravel roof, including two thicknesses of felt, 8 to 10 pounds. These weights do not include any sheathing or furring necessary to carry the roof covering. (*b*) The pressure of wind on a roof is always considered as acting at right angles or normal to the slope, and is taken at maximum when the wind has attained a velocity of 80 miles per hour and exerts a pressure of 40 pounds per sq. ft. on a vertical surface. The slope of the roof determines the effective pressure, and the table below gives the normal pressure on roofs of different slopes, when the wind is exerting a pressure of 40 pounds per sq. ft. on a horizontal plane.

WIND PRESSURE ON ROOFS

Pounds per Square Foot

Rise. Inches per Foot of Run.	Angle With Horizontal.	Pitch. Proportion of Rise to Span.	Wind Pressure. Normal to Slope.
4	18° 25′	⅛	16.8
6	26° 33′	¼	28.7
8	33° 42′	⅓	29.1
12	45° 0′	½	36.1
16	53° 7′	⅝	38.7
18	56° 20′	¾	39.3
24	63° 27′	1	40.0

The snow load is considered as 12 pounds per sq. ft. on roofs having a slope of less than 6 inches of rise for 1 foot of horizontal run, and 8 pounds per sq. ft. for roofs of this pitch and steeper. (*c*) It is an excellent work, and ranks with the best on these subjects. It may be obtained from The Technical Supply Co., Scranton, Pa., for $10.00.

***

(541) (*a*) What is the life of the average galvanized metal shingle? (*b*) Do you consider them as desirable, from an architectural point of view, for covering the roofs of dwellings, as a first-quality cedar shingle? (*c*) Do you know of any rule for proportioning the depth of the cornice to the height of the building? W. C. W., Merrickville, Minn.

ANS.—(*a*) It depends altogether on the atmospheric conditions of the locality in which they are used. If there is much sulphur or carbonic-acid gas in the air, as is usually the case with impoverished air of manufacturing cities, their corrosion is rapid, unless constantly painted, in spite of the galvanizing. From 5 to 15 years would cover the period of their usefulness. (*b*) Cedar shingles are far superior to galvanized metal ones from an architectural point of view, when used as a roof covering of dwellings. (*c*) There are several rules but they have little value. A successful cornice depends on the skill of the designer to grasp the conditions of location and the surroundings, together with his knowledge of the style in which he is working. In dealing with classic and monumental edifices, the proportions of the orders may be followed.

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(542) What is meant by the pitch of a roof; for instance, one-half, one-third, and one-quarter pitch?
S. T., Houston, Texas.

ANS.—The pitch of a roof is the angle the slope makes with the horisontal, and it is usually designated in terms of the rise and the span. If the span is twice the rise, it is called a one-half pitch roof; if three times the rise, a one-third pitch roof, etc.

***

(543) I have a hot-air heater arranged as shown in Fig. 1. It is used for heating a house for chickens. I cannot get the water to circulate through the pipes, *c*, *d*, *e*, and *f* back to the boiler *b*. When the water gets hot it backs up and flows out of the expansion tank *g*, thereby emptying the boiler. The pipes are all ¾ inch, except *f*, which is ½ inch. I cannot get the pipes hot. Please tell me how I can get the water to circulate through the pipes without constant attention.
G. T., Charleston, S. C.

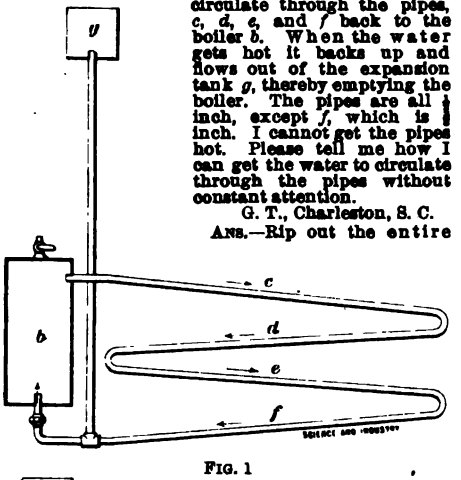

FIG. 1

ANS.—Rip out the entire arrangement and install it as shown by our sketch, Fig. 2, placing the boiler as low as possible, and at least 1 foot lower than the highest pipe in your coil. Use ¾-inch pipe throughout instead of ½-inch and ¾-inch. You will undoubtedly have a good circulation with this simple system, provided that you pitch the pipes constituting the heating coil up toward the point where they join the expansion pipe, so that any air in the coils may work upward and escape into the expansion tank.

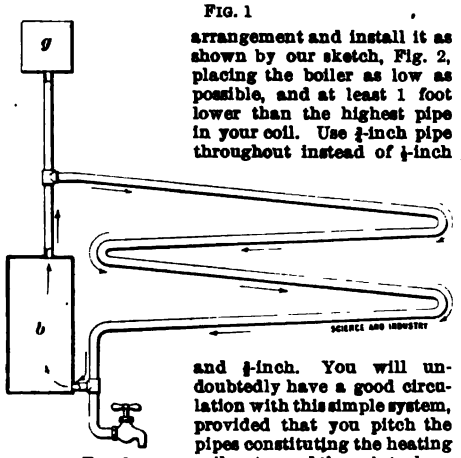

FIG. 2

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(544) Can you give me any information as to the best way of making cement blocks for sidewalks? In cities I have seen blocks of hexagonal form, measuring about 11 inches on the side and 3 or 4 inches thick, and of different colors. Can you inform me of the relative proportion of the ingredients, the method of mixing, and the best way of making the molds? C. F., Guttenberg, Iowa.

ANS.—You will find a description of the general process of constructing sidewalks of this kind, and much other valuable information, in a book entitled "Highway Construction," by Austin T. Byrne. Price $5.00; for sale by The Technical Supply Co., Scranton, Pa. A useful booklet in which is described the process of constructing artificial stone sidewalks will be sent on application by the Buckeye Portland Cement Co., of Bellefontaine, Ohio, and probably by any other company that manufactures Portland cement. The general process is substantially the same when blocks or tiles are used, but the wearing surface is furnished by concrete tiles of a uniform thickness, formed in molds and laid on the concrete foundation, which is brought to an even surface at a distance below the established grade equal to the thickness of the tiles. The tiles can be made any desired form. The molds should be made of dressed lumber and should be accurate as to dimensions. The lower half of the tile should be composed of one part Portland cement to two parts clean sharp sand, thoroughly mixed, using only a small quantity of water, and carefully rammed into the molds. A space about one-half inch in width should be left vacant around the edges. The upper portion and edges should be composed of equal parts of Portland cement and clean sharp sand, thoroughly mixed, using only a small quantity of water, and carefully rammed into the molds, being particular to fill each mold perfectly and to finish the surface smooth. The tiles should be allowed to season at least four weeks before being laid, and should be kept wet the greater portion of the first week. When it is desired to make colored tiles, the sand should be washed clean and clear water used. The coloring materials are given in the booklet mentioned. After the tiles are laid, a thin grouting of neat Portland cement should be spread over the surface and swept into the joints, then all superfluous grouting cleaned off and the walk protected with planks until the cement has set thoroughly.

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(545) Can you assist me in the proper design of a coal bin? The coal is "birdseye" anthracite, weighing 52 lb. per cu. ft. and having an angle of repose of 33 degrees. The amount to be stored is 1,500 tons and the space on the ground available for the bin is 46 ft. square, but the height is not limited. The bottom of the bin will be on the ground, and the problem is how to estimate the pressure on the sides of the bin of that portion of the coal unsupported by the bottom. If we treat the coal as a fluid and compute the strength on that basis, it makes the bin unnecessarily strong and expensive.
J. C. D., Prince Bay, N. Y.

ANS.—While this question is of very considerable interest and importance, it is of a complex character, and any satisfactory treatment of the subject would be entirely too long to be given in our Answers to Inquiries columns. As a matter of information, we will state that much space was given to this subject in Engineering News after the failure on August 14, 1897, of a large coal-storage bin in the boiler house of the Edison Electric Illuminating Company's plant, at Paterson, N. J., described in the issue of that journal for August 26, 1897. The design of the bin was described in the issue of the same journal for September 23, 1897. Then followed a series of communications from a number of correspondents, forming a valuable theoretical discussion of the subject. These appeared in the issues of November 4 and December 30, 1897, and January 27, February 10, March 3, April 7, and May 5, 1898. Information regarding this subject is also given in an article on "The West Superior Coal Storage Plant of the Lehigh Valley Coal Co.," appearing in the Engineering News of August 18, 1898, and in an article on "The Power Station of the Capital Traction Co., Washingto D. C.," appearing in the same journal for January 26, 1899.

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(546) I am anxious to construct a filter large enough to clarify the entire water supply of my house, which has about 20 outlets of various sizes that are frequently in use. My idea is to make it of three sections of flanged iron pipe. These are to be bolted together, and I suppose suitable screens should be placed at the joints. Kindly suggest what these should be, and also indicate the proper filtration materials, such as quartz, animal charcoal, etc. There must, of course, be an equalising plate beneath the intake, and a reservoir at the bottom to receive the filtered water; also some means of reversing the flow, in order to cleanse the apparatus. The latter could be accomplished by a three-way valve. Is the use of alum desirable, and if so, how would you inject the minimum amount, drop by drop, against the water pressure? Could a sight-feed lubricator be used? G. A. D., Philadelphia, Pa.

ANS.—The best thing for you to do in constructing the filter is to look up the patents that have already been granted on filters. They are very numerous, and if you commence building a filter according to your own or our ideas, it is very likely you will infringe upon somebody's patents. The question that must be solved is not how you can build the filter so that it will work satisfactorily, but how you can build it so as to clear other people's patents. This is one reason why we cannot undertake to design your filter.

MISCELLANEOUS

(547) (*a*) How can I make a concave mirror or reflector 20 inches in diameter, with a 5-foot focus? (*b*) If this reflector were placed in bright sunlight would it melt glass at its focal point; if not, how large should it be to do this? (*c*) What is the temperature and specific gravity of liquid air? (*d*) Is the earth as a whole a positive or negative body? (*e*) What is the cost per cubic foot of oxygen and hydrogen gas? MAUD, Lebanon, Kas.

ANS.—(*a*) A parabolic mirror would be best for this purpose. These mirrors may be made of sheet copper spun up in a lathe on an iron form. You will find methods for describing a parabola in almost any book on analytical geometry. The iron form is turned up to agree in outline with the parabola and the copper spun over it. The copper is then silvered by electrodeposition and afterwards highly polished. We think it would pay you far better in the end to buy your mirror from some manufacturer of search lights. Good parabolic mirrors require a great deal of skill for their manufacture. (*b*) We do not know just what temperature this mirror would give, and have been unable to locate any experimental data that would indicate its probable value or that would show how large the mirror should be. Perhaps some of our readers will be able to help you. It would, however, require a very large mirror to give heat sufficient to melt glass, and we do not believe that a 20-inch mirror would come near doing it. The heat obtained will no doubt depend to a great extent upon the character of the surface of the mirror and the exactness with which it brings the rays to a focus. It is our opinion, however, that such a mirror would not melt glass (*c*) The temperature of a saturated vapor of liquid air at atmospheric pressure is about −191° C. Its specific gravity at this temperature is .933. (*d*) The earth is generally assumed to be as a whole at zero potential, i. e., neither positive nor negative. Different points on the earth may, however, have quite different potentials with regard to each other. (*e*) This depends upon how you get the gases, and it is impossible to give any definite figures. You can make the gases by electrolysis for about 2 cents per cubic foot. For prices on these gases we would advise you to write to any firm dealing in stereopticon supplies.

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(548) A question has arisen between two parties regarding the swing of a drawbridge; A claims that when it is turned through the quadrant of a circle from its position when closed to the position when open, in order to allow a vessel to pass through, it makes a half turn, considering the semicircle to constitute a complete turn. B claims that in being turned in this manner the draw makes only a quarter turn, considering the entire circumference to constitute one complete turn. Now, who is right, A or B, or both? G. W. T., Fall River, Mass.

ANS.—B, we should say. The entire question depends on what is meant by *turn*. The first definition of turn given in the Standard Dictionary applies directly to this; it is "*To give a rotary motion to, whether the motion communicated be a complete rotation or not.*" When the bridge is turned from the closed to the open position in order to allow a vessel to pass, that, of itself, constitutes a *complete turn;* that is to say, that particular act of turning is complete, although the bridge does not make a complete revolution, but is turned through one quadrant only. When it is turned again to the closed position, the act is again complete—the bridge is turned completely, though not through a complete revolution. A turn of any amount or degree may be considered as a complete turn. However, it is commonly considered that a complete turn is made when a point on the body turned passes through the complete circumference, that a half turn is made when the point passes through the semicircumference, and that a quarter turn is made when it passes through the quadrant. This view of the matter may be considered correct, since it is according to common usage, although any degree of rotation may be considered to be a complete turn.

***

(549) (*a*) Is a curve on a street railway an arc of a circle, and if not, what is it? (*b*) How many poles are required for one mile of telegraph line of standard construction? C. B. S., Baltimore, Md.

ANS.—(*a*) The curves used on street railways for rounding corners are not usually plain arcs of circles, though on some of the earlier roads they were. Transition curves are now generally used. In the transition curve, a long radius is used at the point where the curve starts and the radius gradually reduced until it becomes equal to the radius of the central part of the curve. In other words, the curve is made up of parts having different radii and the result is that the car enters and leaves the curve much smoother than if a plain circular arc were used. (*b*) It is difficult to give any fixed number for this, as it depends on the nature of the country through which the line is run, and also to some extent on the number of wires that the poles have to carry. For light lines in open country, from 35 to 42 poles per mile are used. For heavier city lines, 40 to 50 poles per mile are used.

***

(550) Please show how to divide the area of a given circle into two equal parts by an arc of a circle, the center of which is on the circumference of the given circle. G. A. N., New York.

ANS.—See answer to question 74 in the March, 1899, number.

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(551) Please give a description of a range finder as used in the navy. C. M., St. Paul, Minn.

ANS.—An excellent article by Mr. Ernest K. Roden on this subject appeared in the August, 1899, number of this magazine.

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(552) (*a*) Please explain the principle and construction of the polyopticon. (*b*) Can the lenses of the microscope be used for projecting views in the same manner as with a magic lantern?

D. P., Lawrenceville, Ill.

ANS.—(*a*) Several optical instruments are manufactured bearing the name of polyopticon, the majority of which are merely toys, and from the nature of your question we assume that you refer to the apparatus used for projecting pictures on a screen without the use of lantern slides. The principle on which the instrument is worked is similar to that of the photographic enlarging camera, with the exception that the pictures are projected on an opaque white screen instead of on the translucent ground glass used in photography. The picture or object to be projected on the screen is brilliantly illuminated by an oil or incandescent lamp, and the light reflected from it passed through an objective and focused on the wall. A plan showing the principle of this arrangement is illustrated in Fig. 1, where the lamp or illuminating power is shown at *a*, behind which is a powerful reflector *b* that throws the

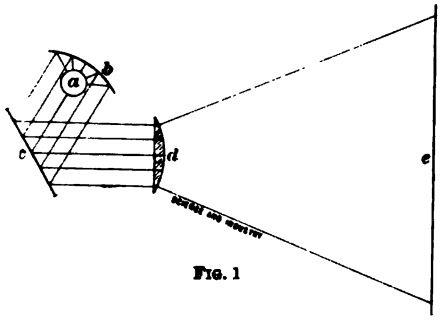

FIG. 1

light against the photograph or picture *c* to be projected. The light is reflected from *c* through a lens or objective placed at *d*, and is projected, much enlarged, as shown at *e*. As the amount of light reflected from *c* varies with the nature of the surface of the picture used, it is advisable to secure photographs with considerable contrast, and confine other views to black-and-white pictures only. Much light is lost by absorption at *c*, and therefore the

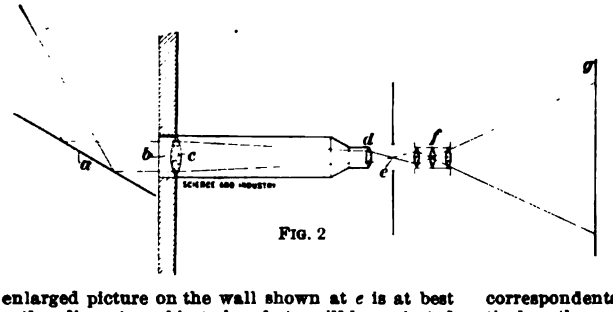

FIG. 2

enlarged picture on the wall shown at *e* is at best rather dim. Any object placed at *c* will be projected on the screen as shown, the brilliancy of its projection varying with the character of its reflecting surface. Line drawings, etchings, and photographs will thus have the appearance of dimly lighted charcoal drawings. As said before, the instrument is scarcely more than a toy, and has never been successfully used for practical demonstration. (*b*) The microscope may be used for projecting views in the same manner as a magic lantern, provided the illuminating power is strong enough. Direct sunlight admitted to a darkened room, or an electric light, may be used in conjunction with an

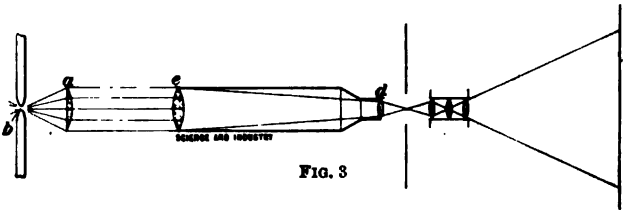

FIG. 3

ordinary microscope to project objects on a screen. Where the apparatus is used in conjunction with sunlight, it is usually termed a solar microscope and is operated on the principle shown in Fig. 2, where at *a* is a mirror outside of a small opening *b* in the partition or window shutter of the room. This mirror is inclined at such an angle that the sun's rays will be reflected from it horisontally through this aperture to a condensing lens at *c*, by means of which the rays are converged to a second condensing lens *d* and brought to a focus at *e*, where the object to be magnified or projected is placed between two plates of glass. On the opposite side of *e* a system of three microscopic condensing lenses is placed, as shown at *f*, and upon the screen at *g* a greatly magnified image is projected. Where the electric arc light is used instead of direct sunlight, an extra condensing lens is required, as shown at *a*, Fig. 3, and the rays from the arc light *b* pass through this lens and are rendered parallel until they reach the lens *c*, and then they are refracted through the lenses *c* and *d* in precisely the same manner as were the sun's rays in the previous case. In this instance the rays from the electric light diverge from the arc at *b*, and the condenser *a* simply renders them parallel, the other details of the instrument being precisely the same as in Fig. 2. The main object to be attained in this work is an exceedingly high illumination of the slide or specimen to be magnified and an arrangement to permit the emerging light rays to pass through three microscopic condensers or objectives to a suitably arranged screen.

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(553) A cubic foot of stone, weighing 100 pounds in air, is dropped from a position of rest at the surface of the sea, in water 32 feet deep. In how many seconds will it reach the bottom, and what will be its velocity in feet per second at a depth of 16 feet, and also when it strikes the bottom? Give the same for another stone twice the cubic contents and twice the weight. Assume the water still and without current.

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ANS.—This is one of many fancy problems we receive from our correspondents. The solution of it involves an exceedingly great amount of labor and is, after all, of no practical value whatever. We would request our correspondents to make their questions more practical, as the answers would then be of interest and value to the majority of our readers. We spare no pains or time in answering questions of the latter kind; but we think it unfair to our subscribers to fill our Answers to Inquiries columns with

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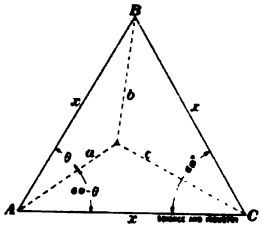
the solutions of ideal problems that probably 99 per cent. of them will not even look at.

***

(554) Given, the distances from a point within to the vertices of an equilateral triangle, to find the length of a side and area of triangle.
C. F. W.,
Oak Park, Ill.



ANS.—Such problems as the above are of no particular value, and are of service merely as exercises of mathematical ingenuity. This one may be solved as follows: Let θ be the angle between AB and a; then that between AC and a is $60-\theta$. From trigonometry, we have

$$c^2 = a^2 + x^2 - 2ax\,(\cos 60 - \theta); \quad (1)$$

and

$$b^2 = a^2 + x^2 - 2ax\cos\theta; \quad (2)$$

$$\cos(60-\theta) = \cos 60\cos\theta + \sin 60\sin\theta. \quad (3)$$

Substituting the value of $\cos(60-\theta)$ from (3), also value of $\cos\theta$ from (2), in (1), and putting known values for $\cos 60$ and $\sin 60$, there results,

$$c^2 = a^2 + x^2 - \frac{(a^2 - b^2 + x^2)}{2} - ax\sqrt{3}\sqrt{1 - \left(\frac{a^2 - b^2 + x^2}{2ax}\right)^2}. \quad (4)$$

Expanding, combining terms, reducing, and solving for x,

$$x = \pm\sqrt{\frac{a^2 + b^2 + c^2}{2} \pm \frac{1}{2}\sqrt{6\,(a^2b^2 + a^2c^2 + b^2c^2) - 3\,(a^4 + b^4 + c^4)}}.$$

The external negative sign must be disregarded. Having found x, the area may be determined by the method used when the three sides of a triangle are given.

***

(555) Where and at what cost can I get a book that gives the name, the supposed depth, and a general account of each successive layer of the rocks that form the earth's crust? A. R., Glasgow, Scotland.

ANS.—The geological formations of the earth are so irregular that it is impossible to give any definite idea of the depth of rocks beneath the surface. The names of the rocks can be obtained from any good book on geology. A good work on this subject is entitled "Revised Text-book of Geology," by Jas. P. Dana. This book can be obtained from The Technical Supply Co., Scranton, Pa., for $1.40. A good English book on the same subject is Geike's "Class Book on Geology"; the price of this book, in English money, is about 4s. The Metal Mining Course of The International Correspondence Schools also contains a very thorough treatment of blowpiping, mineralogy, geology, and prospecting.

***

(556) How is rubber melted, to make rubber stamps? E. P., Ashland, Pa.

ANS.—The rubber is not melted; a thin plate of pure unvulcanized rubber is placed on the mold, put in a press and tightly screwed down so that the rubber is forced into the matrix. Heat is applied to the bottom of the press, and by this means the rubber is vulcanized.

***

(557) Nicola Tesla, when going to school, was in the habit of testing his arithmetical examples by the "rule of three." Will you kindly explain what this rule is? E. A. R., Chicago, Ill.

ANS.—The "rule of three" is the old name that was applied to what we now call proportion—three terms being given to find the fourth.

(558) Which is the best heating system, steam or hot water? Explain why.
W. C. L., Albany, N. Y.

ANS.—Hot water is the better system for warming homes because the temperature of the rooms can be easily regulated, and because the low temperature of the radiators prevents dust, etc. from becoming incinerated on the heating surfaces and thus giving an odor to the air in the rooms. Another point in favor of hot water is that the water will remain hot for a long time after the fire is extinguished. This is valuable for heating at night, because the fire is so uncertain then.

***

(559) What is the total area of 126 circles $\frac{1}{16}$ of an inch in diameter; the diameter of a circle having the same area; also length of side of a square having this area? W. B. S., Hermansville, Mich.

ANS.—The area of a circle $\frac{1}{16}$ of an inch in diameter is $(\frac{1}{16})^2 \times .7854 = .008071$ sq. in.; the area of 126 circles would be $.008071 \times 126 = .386946$ sq. in. The diameter of a circle having this area is $\sqrt{\frac{.386946}{.7854}} = .702$ in. The side of a square having an area of .386946 sq. in. is found by extracting the square root, and is equal to .622 in.

***

(560) Which would travel the farthest in going the distance of a mile, a man in a gig seated exactly over the axle, or a toad seated exactly on the top of the wheel, going around with the wheel as the gig advances? The man and toad to have the same position at the end of the mile as at the start.
A. E. S., Shamokin, Pa.

ANS.—The answer to your question depends altogether on what you mean by the word "distance" when you speak of the distance traveled by the toad. If, by distance, you mean the horizontal distance, then the toad and the man travel exactly the same distance. If by the distance traveled by the toad you mean the whole length of the line described by the toad in space, then the toad travels farther than the man; the line described by the toad is a cycloid, and the length of this line is equal to $\frac{40,000}{31,416}$ times the distance traveled by the man.

***

(561) A pipe having a 2-to-1 slope deflects to the left 45° (read on the plate of the transit) and continues on a 6-to-1 slope. (a) What is the bend in the pipe? (b) If the slope of the ground were uniform, would the angle, read as above, be the bend in the pipe? D. J. McL., Sandon, B. C.

ANS.—(a) By this question we suppose you wish to know the angle measured in the plane of the pipe. It may readily be shown by calculations, too long for insertion here, that the included angle between the two portions of the pipe, measured in their plane, is about 134° 15′. (b) If the slope were uniform, the angle would be greater than 135°, increasing with the steepness.

***

(562) Please give me the proper rule to follow when placing smoke bells over gas lights. Should the bells be placed close to the ceiling or about 1 foot above the gas flame? E. W. B., Chicago, Ill.

ANS.—It is better to place the smoke bells as far below the ceiling as it is possible, without coming too close to the gas flame. A foot or 15 inches, under ordinary circumstances, is a good distance. The object in keeping them as far from the ceiling as possible is to allow the upward current of hot air that rises from the gas flame and strikes against the bell to diffuse as much as possible before it reaches the ceiling. The object of the bell is to prevent the ceiling from being scorched and blackened by smoke.

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SCIENCE AND INDUSTRY

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THE CONSTRAINMENT OF LINKAGES

G. A. Goodenough

DISTINCTION BETWEEN LOCKED, CONSTRAINED, AND UNCONSTRAINED LINKAGES—CONDITIONS REQUIRED TO FIX POINTS IN A PLANE—CRITERION OF CONSTRAINT

ONE of the most interesting subjects included in the *kinematics of machinery* is the constrainment of linkages or mechanisms. If we have given a number of kinematic links, we may connect them in a number of different ways. One method of connection may produce an arrangement of such a nature that the links can have no relative motion whatever; by another arrangement, the links may be free to move relative to each other in fixed predetermined paths; finally, the arrangement may be such that the links are free to move, but the motion is not determinate, and a point on any link may move in any one of an infinite number of paths.

To illustrate these statements, let us take a number of kinematic links and from them build up various linkages and test them for constraint. First, however, it may be well to define clearly what is meant by a kinematic link. A body that is to be used as a member of a machine or mechanism must be provided with suitable means for connection with other bodies; for in machines and even in structures, the various members must be in some manner connected—no member can be isolated. These members must, however, be so connected that relative motion between them is possible. Two members rigidly connected so that no relative motion is possible constitute, to all intents and purposes, a single member. To this end, the members that are to be used as machine parts are provided with certain forms, which permit a desired motion and prevent any other motion. For example, the crosshead of the steam engine carries a pin which fits into a hole or eye in the end of the connecting-rod, and has plane surfaces that fit snugly between other plane surfaces on the guides. The pin and eye permit a rotation of the connecting-rod relative to the crosshead, but no other motion; similarly, the plane surfaces on the crosshead and guides permit a motion of translation and no other. A body thus provided with pins, eyes, or sliding surfaces so that it may be paired with other bodies is called a *kinematic link*.

Let us first consider links carrying only pins and eyes. A link with two such pairing elements may be represented conventionally by a straight bar with two eyes, as shown in Fig. 1; one with three elements by a triangle with eyes at the corners (Fig. 2); one with four elements by a four-sided figure (Fig. 3); and so on.

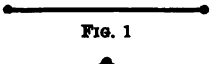

FIG. 1

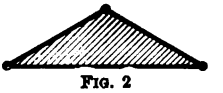

FIG. 2

FIG. 3

Suppose now that there are given six links, as shown in Fig. 4, of which *a* and *b* each have three pairing elements—pins or eyes—and the remaining four each have two pairing elements. These elements are designated by the numbers *1*, *2*, *3*, etc. Let us combine these six links in various ways, and study the constrainment of the linkages thus obtained. In Fig. 5 the element *2* of *a* is joined with *4* of *b*, while the other four elements *1*, *3*, *5*, and *6* are connected in pairs by the links *c*, *d*, *e*, and *f*. The linkage has five joints as shown; one joint is formed by uniting two elements, *2* and *4*; the others have three elements each, viz., *1–11–13*, *6–8–14*, *3–7–9*, *5–10–12*. A joint which, like *2–4*, is composed of *two* elements is called a *binary* joint; one that has *three* elements, a *ternary* joint; and so on. Similarly, links

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carrying two pairing elements, as *c*, *d*, *e*, and *f*, Fig. 4, are binary links; those having three elements, ternary links, etc.

In Fig. 6, the links are joined together so as to form six joints: binary, *1–11*, *2–4*, *6–8*, *5–14*; ternary, *3–7–9*, *10–12–13*.

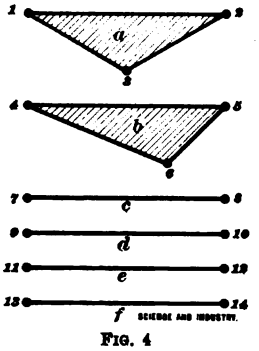

FIG. 4

Figs. 7 and 8 show linkages having seven joints, all binary in each case. In the arrangement shown in Fig. 9, one element of *a* and one of *b* are left unpaired, so that *a* and *b* are essentially binary links, and the linkage consists of six binary links with six binary joints.

It is easily seen that the linkage shown in Fig. 5 is locked; that is, the six links can have no relative motion, and the five joints must maintain their relative positions. Thus the joints *3–7–9* and *6–8–14* cannot approach each other or recede from each other unless the connecting link *c* is bent or broken; for the same reason, *2–4* must remain always at the same distance from *3–7–9* and *6–8–14*. In short, any attempt to move any joint relative to any other is resisted by a tension or thrust in one of the links. That the linkage shown in Fig. 6 is also locked may be shown as follows: Suppose the link *a* to be fixed rigidly, so that it can have no motion. The link *b*, being pivoted at *2–4*, can only rotate about *2–4* as a fixed point; however, the point *6–8* of *b* is restrained from such a rotation because it is kept by the link *c* at a fixed distance from the fixed point *3–7–9*; hence, *6–8* can have no motion relative to *a*, and as a consequence link *b*, having its two points *2–4* and *6–8* fixed, is itself fixed. The joint *10–12–13* is evidently kept in a definite position relative to *5–14* and *1–11*, and since the latter are fixed, *10–12–13* is also fixed. It follows, therefore, that the six joints can have no relative motion, and the linkage is locked.

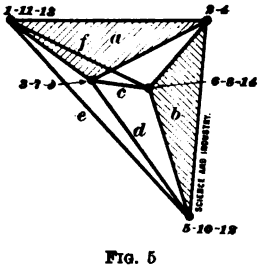

FIG. 5

Consider now the arrangement shown in Fig. 7. Let the link *a* be considered fixed; if, then, the link *c* can move at all, it will rotate about the joint *1–7* as a center, and the point *8–9* will be constrained to move in a circular arc with *1–7* as center; likewise, the end *12–13* of *e* must move in a circular arc with *2–11* as a center. The motion of *b* must be a rotation about *3–6*; hence, *5–10* and *4–14* will move in circular arcs with *3–6* as center. Considering, now, the motion of link *d*, we have seen that two of its points, *8–9* and *5–10*, are constrained to move in definite paths; and since the motion is a plane motion, the motion of these two points determines the motion of *d* as a whole; hence, *d* has a definite constrained motion relative to *a*. By the same reasoning, it can be shown that the link *f* has a constrained motion relative to *a*. Had we taken *b* or *c* or *d* as the stationary link, we could have shown in the same way that each of the moving links has a definite motion relative to the one assumed fixed. The linkage of Fig. 7 has therefore the property that every link has a definite and determinate motion relative to every other link. Such a linkage is said to be *constrained*.

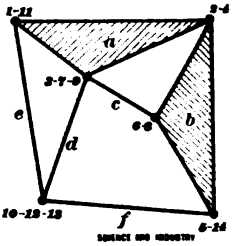

FIG. 6

It is readily seen that the linkage shown in Fig. 8 is also constrained. Turning now to that shown in Fig. 9, we shall find that it is neither locked nor constrained. Suppose that the link *a* is considered stationary; then link *d* must rotate about the joint (*a d*) and the joint (*d e*) must move in a circular arc. Similarly, the joint (*b c*) must move in a circular arc with (*a c*) as a center. These motions are all that we are able to determine. Though we know the motion of one point of *e*—the joint (*d e*)—we know the motion of no other point, and the same is true of link *b*. In fact, the motions of *b*, *e*, and *f* relative to *a* may be anything we choose; that is, we may hold *a* stationary and move *f* into any one of a thousand different positions by as many different paths. The linkage is therefore wholly unconstrained.

The process that we have employed to determine the character of a linkage as regards constraint can be applied with relative ease when the number of links is small; when, however, the number of links is large,

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this elementary method is tedious, and it is necessary or at least desirable to have some criterion that will settle the question of constraint with little labor. We shall therefore attempt to derive some relation between the number of links and joints that will serve as such a criterion.

In Fig. 10 there are four points A, B, C, and D. Let us investigate the number of independent conditions required to make these points occupy always the same position relative to each other. Taking two points, say A and B, just one condition is required, that they shall always occupy the same relative positions, namely, that they shall always be at the same distance apart or that the length of the joining line AB shall be constant. Take now the point C. Its position relative to A and B is fixed when we specify the lengths of the lines AC and BC joining C to A and B, or when we specify the angles α_1 and α_2 which these lines make with the line AB. Hence, to fix the relative position of the three points A, B, and C, *three* conditions are required,

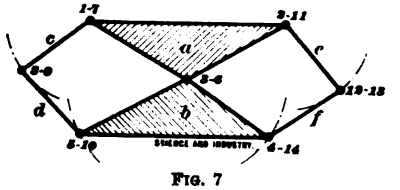

FIG. 7

viz., the lengths AB, AC, and BC, or the length AB and the angles α_1 and α_2. To determine a fourth point D, two additional independent conditions are required: these may be either the lengths AD and BD or the angles α_3 and α_4; or we might locate D from A and C by the distances AD and CD, or from B and C by the lengths BD and CD. Whichever of the three are chosen, only two are required and are independent, and the other condition is dependent upon them. In all, then, *five* conditions are necessary and sufficient to fix four points. A fifth point would require two more independent conditions, or seven in all; and for six points we should require two more, or nine in all. Tabulating results, we have:

Points.	Independent Positions.
2	1
3	3
4	5
5	7
6	9
7	11, etc.

The relation between the number of points and the number of conditions is apparent; the number of conditions is double the number of points less 3. If s denotes the points and c the conditions,

$$c = 2s - 3.$$

Now, in a linkage (Figs. 5–9) the joints are the characteristic points whose relative positions are to be investigated; and the conditions are furnished by the links. Each binary link, as c, d, e, or f, Fig. 4, carries pairs for two joints, and consequently gives one condition. Each ternary link gives three conditions—the distances between the pairing elements. A link with four pairing elements will furnish five conditions, and in general a link with n pairing elements will furnish $2n - 3$ conditions. Take the linkage of Fig. 6, for example. The ternary link a gives three conditions, which keep the three joints *1–11*, *2–4*, and *3–7–9* in definite relative position. The link b gives three more conditions, which are sufficient to fix the positions of the joints *6–8* and *5–14* relative to *2–4*. The link c imposes the one condition that joints *6–8* and *3–7–9* shall remain at a distance equal to the length of c from each other; similarly, the link d fixes the distance of *10–12–13* from *3–7–9*, the link e fixes the distance between *1–11* and *10–12–13*, and the link f fixes the distance between the latter point and the joint *5–14*. In all, then, we have given ten conditions, three each for the links a and b and one each for the links c, d, e, and f. There are six

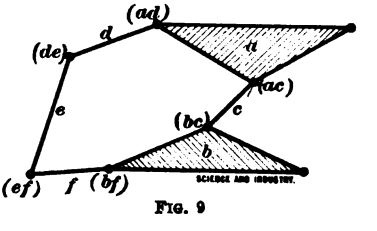

FIG. 8

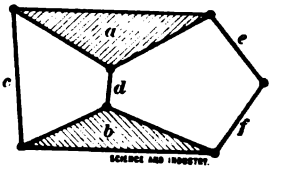

FIG. 9

joints, and to absolutely fix their positions relative to each other, $2 \times 6 - 3 = 9$ conditions are required. We have therefore one more condition than is needed, and the linkage would remain locked if one of the binary links were removed.

In the arrangement of Fig. 5, the five joints require $2 \times 5 - 3 = 7$ conditions to fix them, and as ten are given, three are superfluous, and three binary links could

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be removed without unlocking the linkage.

In the linkage of Fig. 7, on the other hand, the seven joints require $2 \times 7 - 3 = 11$ conditions to fix them; and since only 10 conditions are given, the linkage cannot be locked. When, as in Figs. 7 and 8, the number of conditions available is less by one than the minimum number of conditions required to lock the linkage, the linkage is said to have one *degree of freedom*.

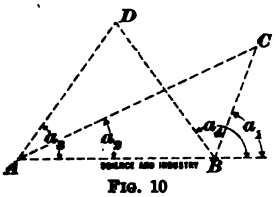

FIG. 10

By this we mean that the joints of the linkage can move relative to each other, but they must move in definite unalterable paths. A linkage with one degree of freedom is a constrained linkage. When the number of conditions available is less by two or any number greater than two than the minimum number of conditions necessary to lock the linkage, the arrangement has two or more degrees of freedom, and is unconstrained. Thus, in the unconstrained linkage shown in Fig. 9, the six joints require to fix them, $2 \times 6 - 3 = 9$ conditions, and only 6 conditions are given.

Let J = number of joints in linkage;
C = number of independent conditions given.

If $C > 2J - 3$, the linkage is locked;
$C = 2J - 4$, the linkage is constrained;
$C < 2J - 4$, the linkage is unconstrained.

We are now prepared to arrive at a formula that will serve as a criterion for the constrainment of any ordinary linkage.

Let N = total number of links in linkage;
J = total number of joints in linkage;
E = number of pairing elements;
n_2, n_3, n_4, etc. = respectively, number of links with 2, 3, 4, etc. pairing elements;
m_2, m_3, m_4, etc. = respectively, joints composed of 2, 3, 4, etc. pairing elements.

Then, $E = 2n_2 + 3n_3 + 4n_4 + \ldots$; (a)
also, $E = 2m_2 + 3m_3 + 4m_4 + \ldots$; (b)
$N = n_2 + n_3 + n_4 + \ldots$; (c)
$J = m_2 + m_3 + m_4 + \ldots$. (d)

Now, since each binary link furnishes one condition, the n_2 binary links furnish n_2 conditions; each ternary link gives 3 conditions, hence n_3 ternary links furnish $3n_3$ conditions; the n_4 links, carrying each 4 pairing elements, furnish $5n_4$ conditions, and so on. The total number of conditions furnished by the N links is therefore

$$C = n_2 + 3n_3 + 5n_4 + 7n_5 + \ldots.$$

If, however, the linkage is constrained,

$$C = 2J - 4;$$

hence,

$$n_2 + 3n_3 + 5n_4 + 7n_5 + \ldots = 2J - 4. \quad (e)$$

This equation is the criterion of constraint.

Sometimes a different form of the criterion is desirable. From equations (c) and (e),

$$n_2 + n_3 + n_4 + n_5 + \ldots = N;$$
$$n_2 + 3n_3 + 5n_4 + 7n_5 + \ldots = 2J - 4;$$

adding,

$$2n_2 + 4n_3 + 6n_4 + 8n_5 + \ldots = 2J - 4 + N. \quad (f)$$

Now, subtracting equation (c) from equation (a),

$$E - N = n_2 + 2n_3 + 3n_4 + 4n_5 + \ldots;$$

whence,

$$2(E - N) = 2n_2 + 4n_3 + 6n_4 + 8n_5 + \ldots.$$

Comparing this with equation (f),

$$2(E - N) = 2J - 4 + N;$$

or,

$$2(E - J) = 3N - 4. \quad (g)$$

In case the joints are all binary, as in Figs. 7 and 8, $E = 2J$ and equation (g) becomes

$$2J = 3N - 4;$$

or,

$$J = \tfrac{3}{2}N - 2. \quad (h)$$

The form (h) is perhaps the one most generally used. Even when ternary joints occur, the formula may be used if each ternary joint is counted as two binary joints. For example, let us apply the formula to the Peaucellier straight-line motion (Fig. 11).

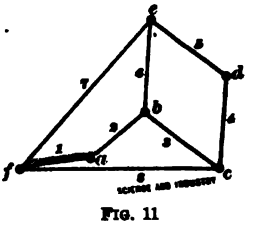

FIG. 11

Since all the links are binary, equation (e) reduces to $n_2 = 2J - 4$;
or, $N = 2J - 4$.

In the linkage, $N = 8$, and $J = 6$; whence, $8 = 2 \times 6 - 4$, and the criterion is satisfied. The number of pairing elements is $2 \times 8 = 16$; applying the form (g), $2(16 - 6) = 3 \times 8 - 4$.

If we count each of the four ternary joints b, c, e, and f as two binary joints, we shall have $J = 10$; and using (h),

$$J = 10 = \tfrac{3}{2} \times 8 - 2.$$

In Fig. 11, length of link 7 = length of link 8, and 3, 4, 5, and 6 are all equal.

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CAR WIRING

Eug. C. Parham

ROOF WIRE—WALL OR POST WIRE—FLOOR WIRE—CONTROLLER, TROLLEY, AND GROUND WIRES—GROUND WIRE PROPER

THE trunk wiring on a car comprises that part of the wiring that is common to both motors—that is, it carries all of the current that the car takes, whether the motors are in series or in multiple. The trunk wire proper extends from the connecting post on the foot of the trolley base to the point where it taps on to the trolley wire that runs from the T post in one controller to the T post in the other, and it is commonly known as the controller trolley wire. The trunk wire includes in its path the two overhead switches, the main motor fuse box, and the lightning arrester; an open circuit anywhere in this path prevents the operation of the car just as effectually as if the trolley wheel were off the wire. The

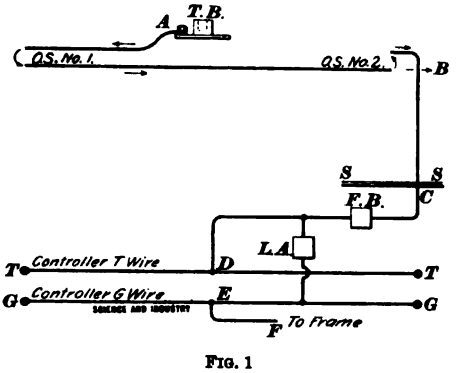

FIG. 1

trunk wire also includes that part of the ground wire that runs from the controller ground wire to the connecting post on the motor frame, or truck, so that the trunk wiring, as a whole, can be divided into four parts: the roof wiring, the wall or post wiring, the floor wiring, and the ground wiring.

Fig. 1 is a diagrammatic sketch of the trunk wiring complete; *T. B.* is the trolley base; *O. S. No. 1* and *O. S. No. 2*, the Nos. 1 and 2 overhead switches; *S. S.*, the line of the car floor; *F. B.*, the main motor fuse box. From *A* to *B* is the roof wiring; from *B* to *C*, the wall or post wiring; from *C* to *D*, the floor wiring; and from *E* to *F*, the ground wire that attaches to the motor or truck.

The roof wire connects at one end to the trolley base and at the other end to the positive side of the No. 2 overhead switch. The roof wire is always made of stranded or flexible cable, because it takes up all the vibration of the car and the blows of the

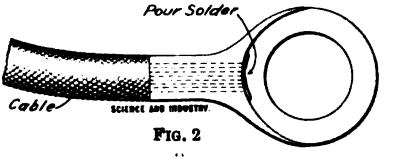

FIG. 2

pole more readily, and is not so liable to break off. On single surface cars, it ranges in size from a No. 0 to a No. 4 B. & S., according to the size of the motors in use, and in any case, unless the same size wire is used throughout the car, for standardization reasons, it should be of twice the cross-section of the motor field or armature leads, because it has to carry twice the current when the motors are in multiple. At both ends, where the connection is made, the cable is skinned, the wires twisted together, and the end dipped in solder, to provide a firm and solid connection.

In some shops, it is the practice to provide the trolley-base end of the roof wire with a regular terminal, such as that shown in Fig. 2. In such a case, this end of the wire is not dipped in solder, but the separate wires are straightened out, run through the hole in the terminal, flared out as shown in Fig. 2, and the hole and end cemented with solder, which must be allowed to harden

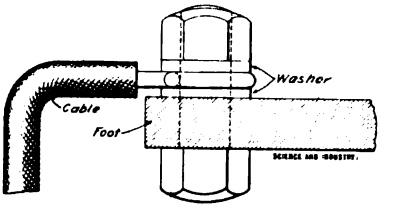

FIG. 3

before throwing the cable down. Where no terminal is used, the insulation is skinned off about 6 inches from the end, dipped into hot solder, trimmed with a file, and bent

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into a gooseneck; the gooseneck or terminal, as the case may be, is held between two washers through which pass a bolt or set-screw that also goes through the trolley foot as shown in Fig. 3. As a further precaution against the bad effects of vibration, it is customary to wind the roof wire into a pig tail of three or four turns just before it is

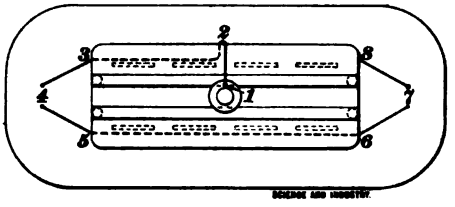

FIG. 4

fastened to the base. Also when fastening a wire down to a connection by means of a bolt or screw, always lay the wire under, so that in tightening up, the motion of the screw will be with the end of the wire and not against it. From the trolley connection, the roof wire goes to the No. 1 overhead switch. The best path to take it is straight across the roof, down to the side of the deck sash, and along the roof beside the deck sash to the end, where it passes down through a hole in the bonnet to the positive side of the No. 1 O. H. switch, as shown in Fig. 4, which is a top view of the car roof, showing the base, the end supported bridge upon which it rests, the outline of the deck roof, and that of the car roof proper. The positions of the deck sash, under the deck roof, are also indicated by the dotted rectangles. The roof wire starts at the trolley base *1*, passes over the edge of the deck roof to the under side *2*; runs alongside of the deck sash, and in such a place that the opening and closing of the sash will not be interfered with, to the end of the deck *3*, from where it passes over the hood to *4*, down through to the No. 1 switch and out again over the hood to *5*; from here it follows along the roof to the other end of the deck *6*; thence across the hood down to and out of the No. 2 switch *7*, and goes to *8*, where it disappears into the end wall of the car. The wire is stretched taut and secured in place by wood or metal cleats. All holes in the roof of the car are filled with white lead, and the whole job is given a coat of roof color. Some workmen seem to think that any sort of a safe job will do on top of the car, where it cannot be seen from below. It can be seen from above, however, which amounts to about the same thing.

The wall or post wire runs from the negative side of the No. 2 overhead switch down through the car floor, and is of the same size and kind as the roof wire. After leaving the hood switch, the wire is either carried to the roof of the hood again, as shown in Fig. 4 (which makes a neat and symmetrical looking job, there being no wires visible from below) or it is run from the switch along the under side of the hood, either in or out of molding, to the point where it starts its downward course. On closed cars, this downward course is through the bulkhead or double-end walls between which the car door slides. On open cars the wire passes into the space between the two walls above the end windows and thence down through a corner post to the space under the end seat; from here it passes through a hole in the car floor to the underneath side of the floor, where it taps on to the floor wiring. Whether the car be open or closed, the hole that passes the wire through the floor should be insulated with a hard-rubber or porcelain bushing, to prevent chafing of the wire's insulation and consequent charging of the car floor or platform in damp weather. If the car is a closed one and the wall wire is passed down through the space that the door slides in, care must be taken to see

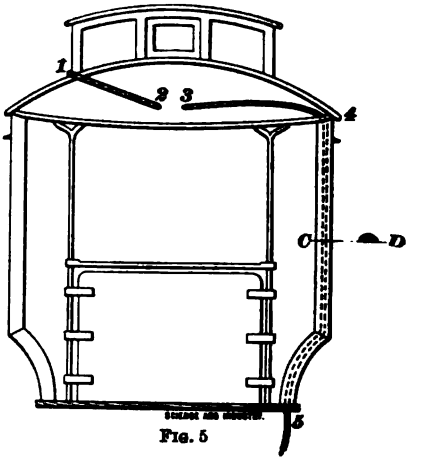

FIG. 5

that the wire is in such a place that it will not interfere with the opening and closing of the door, and that the door roller does not pinch it when the door is slid clean back to the stops. Care must also be exercised to see that none of the screws that hold the register or its rigging go through the wall so far as to come in contact with the wall

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wire, for this will charge the register and rod, and any one touching either in damp weather will get a shock. On open cars, the post wire runs in a groove concealed by the frame strip. To expose the wire, the end window must be lowered and this strip unscrewed and taken off. As a rule, the roof and wall wiring are put in by the car builder; the wall wiring is always installed by him, and need never be disturbed unless it becomes necessary to install a larger wire to meet the requirements of a larger motor, in which case all grooves and holes must be made larger. This will often prove to be a very tedious and unsatisfactory job. In such a case, perhaps as neat and easy a way to run the wire from the roof to the floor is to run it outside altogether. This is done as shown in Fig. 5, by running the wire down one corner of the car, in a cap or molding. The details of construction differ so on different cars that no cast-iron rule can be laid down to cover all cases. The general idea is to select such a path that a simple straight molding can be used. After the wire and molding are in place, a similar piece of molding must be put in the corresponding place on the other side of the car, to deceive the public eye as to its purpose. Fig. 5 is a view of one end of a closed car. The roof wire comes around the corner of the deck sash at *1*; goes through the bonnet roof to the No. 2 switch at *2*; comes out again at *3*; from here it runs across the hood roof to *4* and through the roof again to the mouth of the molding, a section of which is shown through *C D*. The wire passes through the floor of the platform at *5*.

The floor wiring begins where the wall wire comes through the insulator in the car floor and runs by as straight a path as possible, to tap on to the controller trolley wire that runs from one end of the car to the other. Throughout its length it is encased in soft-rubber tubing well taped and shellaced at the ends, to keep the water out. No chances should be taken in any splice or connection involving any part of the trunk wiring proper. All splices should be well wrapped, soldered, trimmed, taped, and shellaced, to make the whole waterproof. To give the joint good shape and to add to its protection, it is a good idea to serve it with thick glossy paper before taping. All stranded wires going into connectors should be twisted together in a compact mass, dipped in hot solder, and trimmed. If the hole in the post or connector is too small to take the wire, do not try to make the wire smaller, but make the hole larger, even if it is necessary to take the device off the car and ream out the hole. The practice of turning back some of the wires of a stranded or flexible cable and cutting them off so as to be able to get the rest of them in the hole, is not safe, and it shows a gross want of regard for good work. The floor wire must be run where it will be out of the way of all brake or sand-box rigging, and it must not be where a heavy load on the car will depress the springs, letting the body down on the wire. On double-truck cars, allowance must be made for the swing of the trucks and the path of the wire selected where it will not be cut off in rounding a curve.

The ground wire proper runs from the controller ground wire to the motor frame or truck. The best place for the ground wire is on the axle side of the motor frame, because there is less motion there. As a further precaution against the jar and vibration shaking the ground wire loose, thereby opening the circuit and disabling the car, it is a good idea to have two ground wires, one to each motor, and these wires should never, under any circumstances, be solid wires; they should be flexible cable.

The part of the ground wire proper that runs from the controller ground wire *E* to the motor frame or truck *F*, Fig. 1, is the most important part of the whole trunk wiring, since it gives more trouble than all the other parts together, on account of being exposed to the weather and water and to so much vibration and jarring.

The controller ground and trolley wires, or the wires *T T* and *G G*, Fig. 1, that run from the *T* and *G* posts on one controller to the *T* and *G* posts on the other controller, are really a part of the trunk wiring, in that they both are called upon to carry the same amount of current—that is, all the current the car takes; but they are not, as a rule, considered as the main trunk line, for at no point on either of these wires will an open circuit totally disable a car, whereas in the main trunk, anywhere from *A* to *D* or from *E* to *F*, an open circuit will entirely cut off the motive power. Only one-half of the *T* or *G* controller wire is used at a time, but since either half must carry the total car current, when used, the cross-section of the whole wire must equal that of the roof and wall wires. An open circuit between *D* and *T*, Fig. 1, will disable the controller on that end of the car, but it does not in any way disable the other end.

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BENEDICT'S EXPERIENCE WITH A HOT-AIR FURNACE

T. N. Thomson

COALING THE FURNACE—THE BEST KIND OF COAL TO USE—HOW TO KEEP FURNACE GAS OUT OF THE HOUSE—THE RIGHT WAY TO SET THE DAMPERS

OUR FRIEND, Mr. Benedict—like all other benedicts of sound sense—immediately started in to "keep house" as soon as the wedding trip was over. The honeymoon was sweet, of course, as all honeymoons ought to be, but when our friend awakened from the ecstasies of connubial bliss and stood face to face with the stern actualities of life in the month of November, he began to realize that there was something else for him to do than coo-coo like a turtle dove all winter—he had the furnace to attend. A cold wave began to play upon their cosy six-room framed cottage, and although their blood was thick and warm, yet the cold air ultimately got the best of them, and Mrs. B. reluctantly suggested that "we get a fire in the heater now."

It was not settled definitely before the union who should attend to the furnace; indeed, Mr. B. had the blind staggers so bad that he never even dreamed of such things before. But now he was "up against" a momentous problem that must affect his life's history—a question the solution of which has caused many a wide breach in domestic happiness. Almost invariably the furnace problem is hitched onto the husband for his sole attention, the good wife not even deigning to look at the galvanized-iron jacketed coal eater as she passes through the cellar. Sometimes, however, the responsibility and labor are lovingly laid upon the shoulders of the young wife, on the ground that the husband does not wish to hamper her in the full performance and control of everything inside the home. But both of these are drastic measures, and neither works satisfactorily in a house without a servant, such as Mr. Benedict's must be, for his salary and prospects did not yet warrant the employment of a servant.

Both Mr. and Mrs. Benedict had been down in the cellar frequently and had seen the octopus-looking monster whose tentacles are 8-inch tin pipes, but they never had any inclination to examine or study it, and consequently the entire heating system was strange to Mr. B. when he was about to "start it up" for the winter.

Of course, the natural reasoning is that the first operation is to start a fire. A few old newspapers, a chopped-up old soap box, and a match quickly accomplished that, and while the wood was still burning Mr. B. shoveled on some coal. He then rushed up stairs to get a breath of fresh air, for a fresh fire is noted for smoking the cellar until the chimney gets warm, and by this time the cellar was filled with smoke.

Mrs. B., in order to let the heat get into the rooms, had turned all the registers full open, and remained in the sitting room on the first floor awaiting developments while Mr. B. continued his coal-heaving task in the cellar. He was congratulating himself on the fine fire that was raging in the furnace, when his better half called down through the register: "John, there is no heat coming up at all. Can I come down and help you?" "Strange," he shouted, stretching his neck upward so that his voice might go through the floor overhead as a bullet goes through a board, "I have a big fire in the old thing, and there must be heat somewhere."

This remark started Mrs. B. out on a search for heat. She anxiously held her hand over the hall register, but it was as cold as the one in the sitting room; then she skipped into the parlor and did the same thing there, and sure enough she could feel an occasional puff of warm air, which almost instantly receded. Then she bounded up stairs to see whether there was any heat in the bed rooms, and to her utter amazement each one was roasting hot, and each one had a strong smell of furnace gas.

Mr. B. was then called up stairs to witness the condition of affairs. After a little discussion they decided to shut the up-stairs registers and see whether the hot air would then go into the lower rooms. As soon as they were closed a little hot air came up the sitting-room register and then stopped, then a little more and again ceased. The same movements occurred at the parlor and hall registers. The result was not satisfactory at

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all, and a furnace man was sent for. By the time he came Mr. B. had almost set fire to the house by overheating the furnace. When the furnaceman arrived he asked a few questions, looked the system over, then opened a slide, and the hot air instantly flowed into the parlor, hall, and sitting room in such a large volume and at such a high temperature that these places were heated to about 80 degrees in a few minutes. Then it was that Mr. B. discovered there is something else in the running of a furnace than the mere act of shoveling coal, and he was wise enough to ask the furnaceman to explain the use of the slide damper he had just pulled out.

"That damper," said the furnaceman, "is placed in the cold-air box for the purpose of regulating the flow of cold air to the heater, where it becomes warmed and rises to the rooms through the tin pipes overhead. Lots of furnacemen imagine that a job won't work right unless a damper is put in the cold-air duct, but in my experience I find that they are dangerous things. Take your case, for instance, Mr. Benedict: you started up the heater with the damper shut tight. Cold air could not come in to supply the furnace from the outer atmosphere, as is intended, so it came down through the sitting room, parlor, and hall registers to take the place of the hot air that flowed up to the bed rooms. It is impossible for hot air to leave a furnace unless a supply of cold air can get in to take its place. Now, if you open all the registers in the house they will give off plenty of hot air."

"Then," queried Mr. B., "what is the use of the slide in the cold-air box?"

"No use at all, sir," replied the furnaceman; "indeed, they are worse than useless, for, when closed while the furnace is running, the draft of the hot-air pipes on the heater draws furnace gases through every crack and crevice of the fire pot and combustion chamber, and poisons the air in the rooms."

"Ah! I see," said Mr. B.; "it causes the pressure of the fresh air around the heater to become less than that in the fire pot, and the gases have to go wherever the pressure is lowest. Is that so?"

"Exactly," replied the furnaceman"; and that occurs frequently when the chimney draft is poor or when the fire door is left open, but worst of all when the check-draft at the back of the heater is open.

"Now, before going, Mr. Benedict, I would say that if you are wise you will not close that slide damper any more this winter." And our furnaceman went off to attend to the troubles of some other people.

When Benedict started his heater he fired furnace coal, but as pea coal is so much cheaper and as his neighbors were using this grade of coal, he thought he would try it too. But alas! one day, about half an hour after he had just filled up the fire pot with pea coal, he opened the fire door and hastily looked in to see how the fire was coming up. Then there came an explosion; a blue flame shot out of the door and singed his hair.

This set Mr. B. to thinking again. Since he commenced to use pea coal the heating of the house had always been spasmodic. It invariably cooled down during the night, and occasionally a peculiar hollow sound, like an explosion in the bowels of the earth, would be distinctly heard upstairs, and furnace gases and soot would at the same instant blow into the rooms from a stove-pipe hole in the chimney, the tin cap that covered the hole being sometimes blown out to the middle of the room.

Looking at the coal bin, he was surprised to find that the pea coal was being consumed much faster than the last ton of furnace coal, and yet the house was not being comfortably heated. Desirous of information, Mr. B. called upon an old friend who, in his younger days, used to fire a boiler. He explained the trouble and asked advice.

"Why, John, old boy," the friend replied, "you're burning the wrong kind of coal."

"But," interrupted John, "there is a difference of $1.20 a ton, and our neighbors burn pea coal."

"That may be, John, but the furnace coal is cheaper in the end, besides being much more satisfactory. It is true that a ton of coal is a ton of coal, whether in big or little pieces, and that each ton contains about the same heating power as the other, but the trouble lies in the burning of them. You will understand that coal requires a certain quantity of fresh air to supply it with the oxygen necessary for combustion. If the proper amount of air gets at the coal, then the coal, if fresh, will break into flame and burn to the best advantage—that is to say, it will give out all the heat it contains; but if the air supply is not great enough to furnish sufficient oxygen to the coal, then the gases given off by the coal will pass up the chimney unconsumed. So your money goes to waste and your house gets cold."

"I understand," interrupted John; "my house gets cold—that's true; and my money

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goes up the chimney—that's ditto, but about what proportion is wasted?"

"Well," continued the friend, "when a pound of coal is properly burned and completely consumed it gives off about 14,500 B. T. U. and"—

"What are they?" queried Benedict.

"Well, well," laughed the friend, "pardon me, Benedict; I forgot that you confined your studies to commerce, and of course cannot be expected to know what B. T. U. means. B stands for British, T for thermal, and U for units."

"British thermal units, eh?" exclaimed Mr. Benedict; "what are they, and why are they not called American thermal units?"

"Hold on, John; one question at a time, please," interrupted the friend, "then you won't get me confused. A British thermal unit is the quantity of heat required to raise the temperature of 1 pound of water 1 degree by the Fahrenheit thermometer, and it is called British because it was first adopted in Britain as the British standard for heat measurement. Later on we required a standard of our own, and we simply borrowed Cousin John's to prevent confusion. Our friends in other countries have other units of heat measurement, and we call ours British just to show that it is not the French or the Russian or the Chinese heat unit that we work on. But that is aside from the question, John—let us get back to your coal bin. I said a pound of coal gives off about 14,500 B. T. U. during the process of complete combustion; but if it does not get enough air to allow complete combustion then a peculiar process of incomplete combustion takes place, and a gas called carbon monoxide leaves the coal and escapes unconsumed, and the heat given off by coal burned this way only amounts to about 4,400 B. T. U.—less than one-third. Now you see how two-thirds of the available heat of your coal can go up the chimney. With furnace coal that waste seldom, if ever, occure, but with pea coal there is more or less waste going on all the time."

"Can that waste be prevented in burning pea coal?" inquired Benedict; "I have about half a ton of pea coal on hand and would like to use it up."

"Yes; it can be prevented by throwing on just a little pea coal at a time, and often—say once every hour during moderately cold weather."

"Whew," whistled Benedict; "I can't stay home all winter to shovel coal. Isn't there some way of overcoming this trouble?"

"Yes," replied his friend; "if the fire pot is big enough you can pile up pea coal on one side of the fire and leave the other half red and free from ashes, so that plenty of air can get through. If you pile up pea coal and neglect to do this, the inside of the furnace will become filled with carbon monoxide and other gases, which will explode when the fire breaks through or when air is admitted to the fire."

"By gum, you struck it, old boy," exclaimed Benedict, removing his hat; "just look at my head and eyebrows."

"You are a lucky dog, Benedict," the friend replied; "you got off easy. Many a man has lost his eyesight in that way."

"But will we get enough heat from pea coal during coldest weather if we fire as you say?" queried Benedict.

"No, sir," emphatically answered his friend; "for by so doing you only utilize half of the grate surface. Manufacturers of furnaces don't build them for pea coal. I would advise you to use furnace coal and nothing else. You will thus save money in the end; besides, it will avoid an immense amount of annoyance, for you can then fire the furnace once a day, or twice at the most."

"Then I suppose we may use up the pea coal in the kitchen range?" queried Benedict.

"Exactly," replied his valuable counsellor.

Benedict followed instructions, and the furnace worked beautifully until the weather became so cold that the thermometer outside registered zero. Then it seemed as though the house could not be heated above 60 degrees. He shoveled on coal to an alarming extent in the morning, before he went to the office, and his wife shoveled on more while he was gone, and the coal bin was being emptied fast. It was evident that something was wrong, and Benedict put on his thinking cap again. He reasoned that as the furnace was being fired as hard as possible, the coal was giving off heat, and he murmured, "where does the heat go?" The chimney draft was excellent, the draft strong, the fire brisk, the smokepipe almost red hot, and the furnace jacket cold. The registers were all full open, and yet the house was cold, and Benedict was again puzzled to know what could be the matter. Being a good business man, he knew enough to call upon the furnaceman that did the job and give him some plain talk.

"Jones," he shouted, as he entered the shop of tin pipes, wash boilers, and furnaces, "I thought you guaranteed that furnace of

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mine to heat the house to 70 degrees during zero weather."

"So I did," replied Jones, "and I do yet; what's the matter with it?"

"Matter enough," shouted Benedict, now in a medium rage, "we've stuffed about a ton of coal into the old thing these last two days and the house is like a refrigerator yet. See here, Jones, if you want to keep a good reputation, you will come up to the house with me right away and prove that your guarantee is O. K. The weather conditions are favorable. Come on."

"All right," meekly replied Jones, and the two hurried up to Benedict's home. Down in the cellar, the furnace doctor hastily looked around and "took in" everything, so to speak. He looked at the fire and remarked that it was brisk enough to heat a house twice the size of Benedict's. Then he felt the hot-air pipes, which were quite cold. He looked for the damper of the cold-air duct and observed that it was pulled out and probably thrown away, but he made no remark, for personally he prefers no damper there, although his men usually put them in to please customers. Then he went upstairs and held his hand over each register, to feel the draft, and he knew the trouble.

"Mr. Benedict," he thoughtfully remarked, "I will check down your registers a little, to prevent the cold air from rushing so rapidly through the furnace, which will give it more time to heat. This will allow a smaller volume of air at a much higher temperature to enter the rooms, and will make a great difference."

This was done and the air immediately came up the registers "piping hot"—so hot that the fire in the furnace had to be checked to prevent overheating the house.

Jones' reputation was saved because he knew what the trouble was, and how to cure it. And Benedict, although feeling cheap, agreed that Jones knew his business and that his guarantee was O. K.

Before Jones returned to the shop he smoked two of Benedict's best cigars, and while smoking presented a great deal of useful information about the running of a furnace, which, condensed, is about as follows:

Keep the furnace clean outside and inside. It is part of the house. Do not let the ashes accumulate in the ash pit, or the grates will soon burn out.

Fire lightly and often if you can, and you will not use so much coal. If you must fire thick, pile it up first on one side then on the other. This will give you fire on top all the time; otherwise the fire will be alternately dead and alive on top and the heating results will be intermittent.

Keep the fire door shut. If you want to deaden the fire, do so by closing the bottom door only. If this will not shut tight enough, you had better get the furnaceman to make it fit close.

Never open the check draft at the back of the heater, otherwise this will allow furnace gases to flow through the joints of the furnace and poison the fresh air that comes up the registers; rather open the by-pass damper that is fitted to all modern furnaces to prevent ash dust from getting into the cellar when the grates are shaken. This should check the draft.

Do not use a damper in the cold-air box, but regulate your heat at the registers. This is the best safeguard against furnace gases getting into the house.

Keep the water tank filled with water, to moisten the air, for in winter the hot air is too dry.

Keep the ground around the mouth of the fresh-air box clean.

Do not sweep dirt from the floors into the registers.

Train your wife to run the furnace when you are sick.

Finally, do not jump on the furnaceman because you cannot run your own furnace.

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THE REVOLVING PENDULUM GOVERNOR

C. Prentur

THE REVOLVING PENDULUM — SIMPLE REVOLVING PENDULUM GOVERNOR — WEIGHTED PENDULUM GOVERNOR — SPRING-LOADED PENDULUM GOVERNOR

MOST steam-engine governors depend for their action on the effect which the centrifugal force that is developed in a weight revolving around an axis outside of its center of gravity has in overcoming a varying resisting force. The weight is so suspended that the centrifugal force developed by its rotation is opposed by a variable resistance. When the speed and centrifugal force increase, the weight moves outward, and the resistance increases until it balances the increased centrifugal force; when the speed decreases, the centrifugal force becomes less than the resistance, and the weight is forced toward the axis; as the weight moves toward the axis, the resistance decreases until it is again balanced by the centrifugal force in the new position. This motion of the weight is transmitted by a suitable mechanism to the valve that controls the flow of steam to the cylinder.

The earliest and one of the simplest steam-engine governors is an application of what is scientifically known as the revolving pendulum, which is shown in Fig. 1. It consists of a weight B suspended from the point O by a fine cord, and revolves around the vertical axis OC. When the pendulum revolves about the axis at a uniform speed, the ball remains at a constant distance from the axis and at a constant distance OC below the point of suspension O. The latter distance is called the *height* of the pendulum, and is represented in the figure by h.

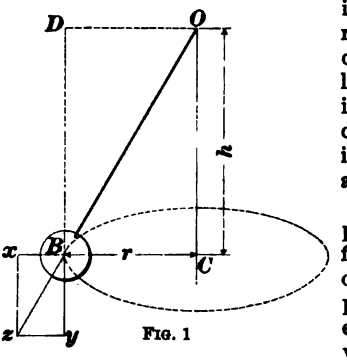

FIG. 1

When the pendulum is revolving, the ball is acted on by three forces, namely: gravity, which is equal to the weight of the ball and acts downward; centrifugal force, which acts horizontally outward; and the pull in the cord. These three forces may be respectively represented by the lines By, Bx, and Bz. Considering the point of suspension O as a fulcrum, it is evident that the force represented by By—the weight of the ball—tends to revolve the ball downward with O as a center, and a lever arm r equal to the perpendicular distance DO from the line of action of the force to the fulcrum. Similarly, the centrifugal force—represented by the line Bx—tends to revolve the ball in an upward direction around O with a lever arm equal to the height h. Since the force represented by Bz acts along a line passing through O, it has no tendency to rotate the ball around that center; it is, therefore, evident that the ball will be in equilibrium when the product of the centrifugal force multiplied by the distance h is just equal to the product of the weight of the ball multiplied by the distance r.

If the centrifugal force is increased by an increase in the speed of rotation, the ball moves outward; as a result, the length of the lever arm r is increased while h is diminished until the turning effects of the two forces are again equalized.

Fig. 2 shows a revolving pendulum as applied to a form of governor much used on Corliss engines. For the purpose of making the governor symmetrical and preventing the bending action on the spindle that would result from the effect of a single weight, two balls B, B are used. These balls are suspended from the collar C_1 that is fastened to and rotates with the spindle S. Links l, l connect the arms to which the balls are attached to a collar C_2 that turns freely on the sleeve U. This sleeve does not rotate, but is free to slide up and down on the spindle. When the balls fly outward the sleeve is pulled upward by the links l, l and the collar C_2. This motion is transmitted to the valve gear by the connecting links and arms.

To prevent sudden fluctuations of the governor, a rod R_2 operates a piston in a cylinder filled with oil. A small opening, either through the piston or through a passage outside of the cylinder, connects

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the spaces above and below the piston in the cylinder. As the piston moves up or down in the cylinder, the oil flows from one side to the other through the small passage.

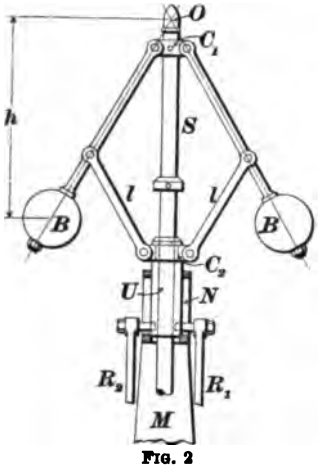

FIG. 2

By regulating the size of the opening the rate of flow of the oil and, in consequence, the rate of motion of the piston can be regulated.

From what has been said, it is evident that the weights of a centrifugal governor can change their position with respect to the axis only when there is a change in their speed of rotation; it is, consequently, evident that such a governor cannot keep the speed of an engine at an absolutely uniform rate under all loads. For example, consider an engine with a throttling governor: when the engine is running "light" —without any load—the governor valve will be opened just wide enough to admit the steam required to overcome the frictional resistances in the engine and keep it running at a uniform speed. When the engine is "loaded," the valve must be opened wider, in order to admit the steam required to do the extra work. This variation in the opening of the valve can be accomplished only by a change in the position of the governor weights, and this change can take place only when the speed of the engine changes. For some purposes a considerable variation in speed is permissible, but in most cases it is desirable to keep the range between the speeds at no load and full load as small as is practicable; for example, in electric lighting, a total range in speed of 4 per cent. cannot be exceeded without causing a disagreeable flickering in the lights. For a given change in speed, the change in position of the weights of a simple pendulum governor is relatively very small, and the relative change decreases rapidly as the speed of rotation of the governor increases. For example, with a total variation in speed of 4 per cent., the theoretical variation in the height h (see Fig. 1) of a simple revolving pendulum is only .57 inch when the weight makes 50 revolutions per minute, and at 200 revolutions the variation in height is only .035 in. From this it is evident that a governor of this type is impracticable for high speeds, and even at low speeds the range in motion for a permissible range in speed is so small that it is difficult to move the controlling valve through a distance great enough to give a satisfactory range in opening.

Another defect in the simple pendulum governor is the fact that gravity—the force that acts in opposition to the centrifugal force developed by the rotation of the weights—is too small to quickly overcome the inertia of the weights when there is a sudden reduction in the centrifugal force. This makes the action of the governor slow in responding to a sudden decrease in load;

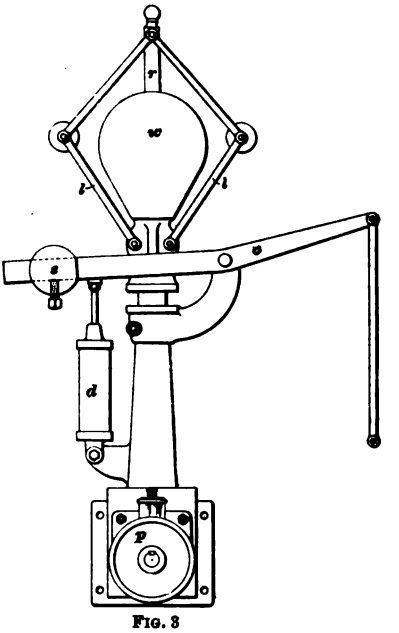

FIG. 3

the result is that before the governor can move far enough to open the valve and admit the steam required for the greater load, the speed of the engine will drop considerably below that corresponding to the

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load. Any attempt to make the governor act more promptly by increasing the weights will be futile, since the mass whose inertia must be overcome is increased in the same proportion as the increase in weight.

The weighted pendulum governor, also called the Porter governor from the name of

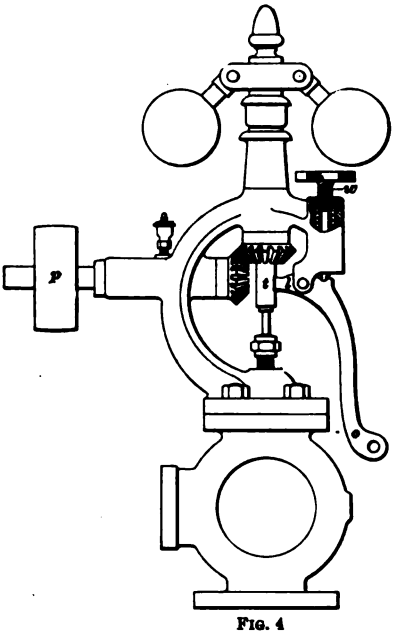

FIG. 4

its inventor, is a modification of the simple pendulum governor that adds greatly to the range of motion of the centrifugal weights for a given range in speed. In this governor (see FIG. 3, which shows the form in which it is applied to the Porter-Allen engine) the centrifugal weights are small and their centrifugal force is made comparatively great by running them at a high speed. In addition to their own weight, the balls must lift a large weight or counterpoise w that is free to slide up and down on the spindle r and is lifted by means of the links l, l. The counterpoise w revolves with the spindle. At its lower end it is fitted with a collar that gives motion to the lever o which transmits the motion to the gearing that operates the valve. The lever o carries a weight s that can be adjusted along the lever so as to change the speed at which the engine will run by a small amount. The dashpot d checks any tendency of the governor to fluctuate too rapidly. The governor is driven by a belt from a pulley on the engine shaft to the pulley p which drives the spindle r by means of a pair of bevel gears.

The effect of the counterpoise is to add to the resistance against which the centrifugal force developed by the rotation of the balls must act, without changing the centrifugal force itself, as would be the case if extra weight were added to the balls. The result is that the balls must revolve at a higher speed in order to develop a centrifugal force great enough to overcome the added resistance. The change in the height of the governor for a given change in speed of rotation is also greatly increased. This is called *increasing the sensitiveness of the governor.*

Instead of the counterpoise, springs are often used for increasing the resistance opposing the centrifugal force of the revolving weights of a pendulum governor. Fig. 4 shows a form of the Gardner throttling governor with a helical spring enclosed in a case provided with a hand wheel and screw w by means of which the amount of compression of the spring, and, in consequence, the resistance can be varied. By

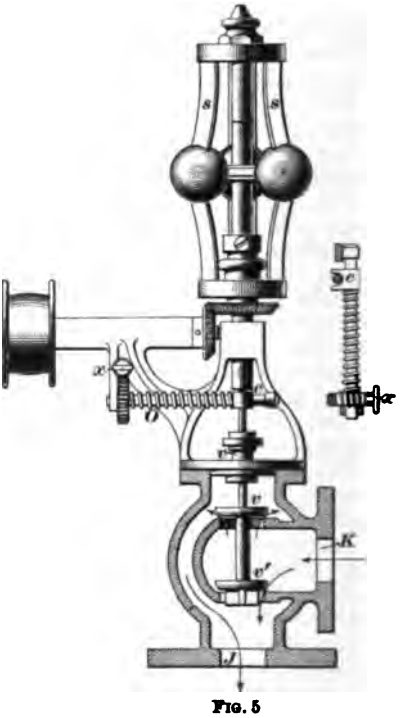

FIG. 5

changing the compression of the spring the speed of the engine can be varied through a wide range. The spindle and fly balls are driven through the bevel gears by a belt on the pulley p. As the balls fly outward they force the spindle t downward; this operates

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the lever *l* and compresses the spring, which thus acts to oppose the outward motion of the balls. The motion of the spindle is transmitted to the valve by means of the valve stem attached to the lower end of the spindle.

The extension *o* of the lever *l* provides a means of attaching a cord or other connection by means of which the speed of the engine can be controlled from a distance. This device, which is much used in connection with engines for driving saw mills, is called a sawyer's lever.

Fig. 5 shows the Pickering governor, which has three fly balls attached to the flat springs *s*, *s*. In this governor the resisting force is furnished almost entirely by the resistance of the springs, and is but little affected by the weight of the balls. As a means of varying the resistance and the speed of the engine, the governor is provided with a coil spring *O* wound around a spindle that carries the fork *e*. The tension of the spring presses this fork upward against the governor spindle, and thus increases the resistance in proportion to the tension, which may be regulated by the worm-wheel and worm operated by the hand wheel *x*.

As the governor balls move outward against the resistance of the springs, they lower the valves *v* and *v'*, and thus partially shut off the steam supply. Steam enters at *K*, flows in the direction of the arrows and then through the opening *J* to the steam chest. The two valves *v* and *v'* are *balanced;* that is, the pressure on the top of one is balanced by an equal pressure on the lower side of the other; this makes the resistance to their motion very small and makes it possible for the governor to handle them easily.

The spring of the spring-loaded governor serves nearly the same purpose as the counterpoise of the weighted-pendulum governor. The spring-loaded governor, therefore, shares with the weighted-pendulum governor the advantages of a high speed of rotation and a high degree of sensitiveness. With the spring-loaded governor, however, the force opposing the centrifugal effect of the fly balls can be made as great as is desired without the necessity of introducing a heavy weight whose inertia must be overcome by comparatively small forces before the governor can respond to a change in speed. Further, after the weights of a governor have been set in motion, their inertia must be overcome before they can be brought to rest in the position corresponding to the change in speed; the consequence is that if a heavy weight like the counterpoise of a weighted-pendulum governor is used, its inertia tends to carry the governor beyond the correct position and the valve is opened or closed more than enough to meet the change in load. This results in a change in speed that carries the governor in the opposite direction and a series of fluctuations in speed and governor positions known as *hunting* or *racing* are set up. A dashpot tends to obviate this trouble by introducing a resistance that prevents the parts of the governor from attaining a high speed and consequently a large amount of energy to be overcome. Such a resistance, however, while it prevents violent fluctuations and hunting, makes the governor slower in adjusting itself to a change in load and so reduces the closeness of regulation that may be obtained, unless a very heavy flywheel is used. With the comparatively light weights of a spring-loaded governor, the momentum of the moving parts is made small in proportion to the forces and resistances to be overcome; this type of governor, therefore, responds more quickly to changes in speed and is much less subject to a tendency to hunt.

Another advantage of the spring-loaded governor is the facility with which the speed of the engine can be changed by changing the tension of the spring.

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HOW TO SUCCEED IN PRIVATE STUDIES

T. Sharper Knowlson
(*Author of "The Art of Thinking"*)

I. A Talk About Methods of Work

I WELL remember the time when, as a youth of seventeen, I first came across that famous book, Todd's "Student's Manual." So keen was my thirst for knowledge in those days that I smile now to think of the intellectual rapture which the manual produced in my ardent mind. I began to buy such books as my small means would allow, and marked them with the Todd system of hieroglyphics. I tried to multiply my ideas, with painful regard for the author's rules, rising to meditate at an early hour, and like a certain Greek philosopher, examining my thoughts at the close of the day.

It is the fashion nowadays to sneer at Todd and his manual, and there can be no doubt that in many respects the book and its writer are sadly out of date. At the same time the *idea* is good: what it requires is *modernizing*. Now, one of the chief merits of Todd's manual is its inculcation of the necessity of method in work. We may look upon him as an old fogy and his system as a mass of conceit, but we shall never get beyond the need of method. "Make the most of time," says Goethe, "it flies so fast. Yet method will teach you to win time." Talleyrand remarks, "Methods are the masters of masters." Hence my first suggestion is:

1. *Have a set time for work.*

It is not the slightest use kicking against system in these days of haste and hurry. If you want to get on you will have to work, and if your work is to be a success it must be done in a systematic manner. Think for a moment of the great business concerns of the United States. Take the railroads as an example. Could they do without a time-table? Once the permanent track is laid and the cars provided, the timetable becomes the very textbook of railway business. The same remarks apply to those huge stores which call forth the wonder of Europeans. I hear you saying, "But I have so little time for private study." Exactly; all the more reason why you should carefully map out the use of every moment. Have you two hours a day for the study of engineering? or mining? or journalism? or elocution? Then form your plan *and stick to it.*

2. *Follow that method of study which experience proves to be best.*

When I was at college there were some students whom we called "night birds," because they could always do more work in the late evening than in the early morning. Speaking for myself, I always found the hours before 7 A. M. the best for study, but all men are not built the same way; there are a good many who, like Charles Lamb, do not care to rise until they have digested their dreams and given the day a little time in which to get "aired." Each man is a law unto himself.

Method not only has an element of time in it, but it has to do with the way of carrying a programme of study. There is a right way and a wrong way of doing most things—everybody will concede that. But there are also individual peculiarities in the habits of students which in spite of repression persist in asserting themselves. We may call these habits the personal equation. One man cannot read unless the light is directly over his head; another man likes to change his subjects every forty-five minutes; and a third man says he abominates electricity in the evenings. Well, it may be a pity that these things *are* so; and that they should be fought against need hardly be said; but there they are, and every student must follow his own plan. Do not ape anybody. If Zola cannot write in daylight, that is no reason why you should enlarge your gas bill; and if John Fiske prefers to study in a draft there is no justification in your running the risk of catching cold.

3. *Success consists largely in knowing where to find the right books.*

Let us suppose you are about to begin the study of political economy in particular and social questions in general. You go to the library and look through the catalogue. There are a good number of books on these subjects and you are at a loss to know which of them to take out. The librarian is perhaps away, or is too busy, and the assistant is not always an authority. What are you to do? You are to become acquainted with the fact that many good guides to reading courses exist, and that if you consult these

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you will save your time as well as your patience. To begin with, there is Baldwin's "The Book-Lover," a useful little manual containing sound advice as to books dealing with pure literature. Then there is Baldwin's "A Guide to Systematic Reading of the Encyclopædia Britannica," which is really a fine work—one of the most useful that could possibly be devised. But this author's work is quite insignificant by the side of Sonnenschein's "Best Books," published in two volumes, and later in volumes referring to specific subjects. If you are interested in science you can buy the section set apart for that subject and at once lay your hand on the best books for your purpose. In an age like this such an advantage is nothing short of superlative. So to come back to the question before us: if you want to find out the best books in economics, go at once to the bibliographies, consult Baldwin, consult Bowker and Iles' "Readers' Guide to Economics"—consult them all.

Now it may happen that the latest books (and perhaps the best) are not included in these guides. What then? Well, all you have to do is to pay a few cents a month for a book bulletin and note the volumes which are likely to interest you by blue penciling the title. Should you meet with reviews, cut them out and keep them by you. Personally, I am very thankful to the reviewers, for they have saved my money by giving an outline of the book under notice, an outline which decided me not to buy. Of course, the reviewer has sometimes made me buy when I was hardly ready to do so; hence, their criticisms cut both ways. Publishers are not unwilling to send you their catalogues, and a perusal of these will keep you up to date. My shelves groan under the weight of catalogues from the ancient house of Murray to the most modern ventures in lonely places among the States, but I have felt the value they have been to me over and over again. As a Britisher, it has given me a first-hand acquaintance with literary impulses all over the North American continent, and although my friends smile at my Yankee enthusiasm, I venture to say that in 15 years' time no country will produce better works of criticism and of creative genius than the United States of America.

4. *Do not despise notebooks, and let your reading be topical.*

Jot down everything that is likely to be useful. In going over one of my notebooks, filled during the early "nineties," I have been amazed to find what an interesting document it is, containing as it does notes on every conceivable subject, from telegraphy to the nature of gossamer, and from an oyster to an archangel. But "interesting" is not the word: it ought to be "invaluable." I have six large manuscript notebooks, and I would not part with them for a thousand dollars. They are all indexed according to subject, author, and book from which the note is taken, so that I can turn up a quotation at a moment's notice. These notebooks form the concentrated essence of my reading for ten years. Perhaps I ought to apologize for writing in this egoist strain, but I do so of set purpose, because I have found that I learned most from writers who told me in a simple way the story of their own experience.

Topical reading is really the best form of study nowadays. You can never hope to know more than one subject thoroughly, so great is the sphere of knowledge. If your subject is biology, stick to it; do not let it go. Worry it until it gives you its secret. You will get far more respect if you are an expert in *something* than if you are a smatterer in everything. Of course, you will read in other directions for the sake of change, and in order to avoid the mental catastrophe that overtook Darwin through a one-sided devotion to science. But even when you read "for change," do it according to system. If poetry claims your attention, do not dip into Byron, then into Browning, and then into Blake; take one poet at a time; catch his spirit, study his methods, contemplate his views of life.

5. *Remember the vital importance of health.*

It is still true that there is a struggle for life and the weakest go to the wall. Only the fittest survive the strain of our heated civilization. So, my young friend, leave a margin in your life for recreation. Do not begrudge an hour on the cycle; it is better than an hour with dyspepsia. Keep your body sound whatever else you do, or your ambitions will die at their birth and the flowers of life will turn to dust.

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ELECTRICAL EQUIPMENTS

Thomas H. Cooper

THE INSTALLATION OF BELLS, ANNUNCIATORS, AND BURGLAR ALARMS IN THE HALF-TIMBERED COTTAGE—A WORD OF WARNING

THE subject of this, the third and last article on the electrical work in the half-timbered cottage, is one that will in all probability be even more interesting than that of electric lighting, since, no matter where the cottage is built or whether or not it is provided with electric lights, every owner will surely want the convenience of the call system and the protection afforded by the burglar-alarm system against the visit of an uninvited guest during the night.

It is customary to slight wiring of this nature because, owing to the low tension and small volume of the current, there is no inspection of it. Any wire, any batteries, any fixtures are deemed good enough, and, worse than all, any boy or cobbler is considered capable of executing the work. If they do not succeed in executing it they certainly do succeed in murdering it. We offer an earnest word of warning against these false ideas. The very fact that a low-tension current is employed is sufficient reason why the material employed should be the best obtainable, and, above all, why the work should be done by an experienced person; otherwise, the work will always be unsatisfactory and the burglar-alarm system will be worse than useless, because the occupants of the house will be depending on a very unreliable agency. Ignorance and false economy in this particular make one of the most desirable of modern improvements a dangerous and temper-provoking nuisance and a constant source of expense for repairs. We do not mean that it is necessary to go to the same expense here as in the lighting but it is desirable that the wires should be enveloped in a tube instead of being concealed and stapled fast so that they cannot be withdrawn and new ones inserted in their stead. Since the wires are small in cross-section and therefore mechanically weak, they should be so installed that an open or cross-circuit can be located readily and repaired without tearing up the floors and channeling the walls. The expenditure of a few extra dollars in these particulars is a good investment. The best way to install these wires is to place them in pipes—either plain iron or brass or iron-armored conduit—but as this entails a great deal of expense, we shall leave it out of our calculations entirely, as we are generally compelled to do in practice, and endeavor to show how the work can be done at small expense and still be satisfactory.

Since the source of current supply is the point to which our attention is first directed when trying to locate trouble, it should be the first in our calculations. It will, in this case, consist of 6 primary batteries, connected in two series of 3 cells each, one set to supply current for the call system and the other for the burglar-alarm system. We can use either so-called dry or wet cells for the batteries. The first are small, clean, and cheap, but their life is short and recharging them is not a practical proposition; it is therefore better to use good wet cells of long life and great recuperative power, and install them in a cool, dry place. The best place for them in this cottage is the cellar, where a closet with a door and two shelves, each large enough to hold one set of cells, may be placed on brackets at some convenient point. These batteries will supply current for two years, provided the current for which they were designed is not exceeded. When they show signs of weakening, which is apparent in the feeble ringing of the bells, they may be taken apart, all parts washed in clean warm water, the zincs and carbons scraped, 4 ounces of sal ammoniac put in each jar, the jars filled to the water line with clean cold water, and the elements replaced, when they will be found to be as good as ever.

The next matter to receive attention is the wire. The one usually used has an insulation of single or double cotton braid soaked in paraffin, but a No. 18 B. & S. gauge copper wire with an insulation of damp-proof compound and an outer braid is much to be preferred. This is called damp-proof office wire, and the cost per pound is the same as for the annunciator wire, but the weight per foot is more, on account of the additional insulation, which makes it more costly.

Two annunciators will be required. The one for the call system will be the ordinary instrument, with a case to match the trim in the kitchen, in which it will be placed. The

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one for the burglar-alarm system will be equipped with two switches and a clock. The clock is not of vital importance, but it is installed in the face of the instrument so that the time of the alarm can be ascertained readily; it also operates a device for cutting the annunciator out of service at a given hour in the morning, so that the servants can open the house without disturbing the sleeping occupants. One switch is to cut the instrument out of circuit for the day, so that the doors and windows may be opened and closed at will; it is closed at night, and if any door or window has been carelessly left open it will indicate which one it is. The second switch is called the constant-ringing switch, and if any drop falls when it is set, the bell will ring until the switch is opened or the drop reset. This instrument does not require any extra wiring, as the several special devices are wired when it is built. In choosing these annunciators, take those that are strongly and simply made and require a minimum of battery power to operate. The window catches and door springs should be strongly made to resist wear, and be positive and free in action to insure an alarm being given when they are disturbed. All bells are to be of the iron box and frame pattern, with double magnet coils and pivoted armature with two adjustments. The platinum breaking contact should be generous in size to resist the burning action of the current.

The insulation of the wires for the battery lines in this work should be of different colors so that they can be distinguished easily at all outlets. The wiring will be done when the floorbeams and partition studdings are in place, but before any lath and plaster are in. Care must be taken to run the wires in such a manner that other mechanics will not cut or disturb them, and they must be kept away from the damp plaster as much as possible. The wires are to be bunched in cables; to do this, run all branches to a convenient central point on each floor and there form them into cables by binding them together with tape. The outlets, which will have a tape cover to prevent abrasion and help keep out moisture, are brought through the plaster and fastened with a staple. Tape should always be used under each uninsulated staple, which should not be driven with sufficient force to cut the insulation. A piece of board should be nailed on the studs back of the lath line, to provide a backing for the annunciators, buttons, bells, etc., and the wires brought through these and fastened so that they cannot be pushed back out of reach. It is preferable to carry the wires through holes in the floorbeams rather than to staple them to the faces, as in the latter position they are sure to be injured. In making taps and splices, care must be taken to make a good contact. Soldering makes the best joint, but if the wires are cleaned until they are bright, tightly twisted together, and the joint covered with tin foil and well taped, no trouble will be experienced.

Care must be exercised to place the door springs at a point on the jamb where the door is not liable to spring, as this would be equivalent to opening the doors as far as the alarm is concerned. The best place for the window catches is at a point on the case where they will be entirely covered by the sashes, the sash being cut out the length of the catch. It is easier to set them just above the lower sash, but the gentlemen of the mask have been known to display a fondness for experimenting with these fixtures, and very often under their manipulation they get out of order and do not send in an alarm when the sash is raised. The upper and lower sash should both be protected and the wires run in a pocket, so that they will not be broken by the sash weights when traveling up and down. Have the wires at the outlet about 8 inches long, so that bad ends may be cut off and the proper connections made. When connecting, scrape the insulation from the wires, so that they are bright and clean, and clamp them firmly under the binding screws. Remember that poor and imperfect connections mean resistance, and resistance makes more work for the batteries.

When the wiring is complete, a test of it should be made. To do this, connect the batteries and attach the battery leads; connect a bell at the annunciator outlet by fastening the battery wire to one binding post and the other wires to the other binding posts in succession. Here the wisdom of using different colored wires for the battery lines will be apparent. Now close the section outlets one at a time; the bell should ring each time an outlet is closed on the section whose annunciator lead is connected to the bell. This operation should be repeated until all sections have been tested. If the bell rings with the outlet ends open, it is because of a short circuit on these wires; if the bell does not ring at all, it indicates that there is an open circuit or that the battery leads are short-circuited, which will

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be indicated by a spark when one end of the battery lead is loosened. Many other troubles may prevent the bell from ringing, but these are the most common ones. Each battery lead should now be tested with a magneto for a ground, and if any is found to exist it should be removed, because it will "pull the batteries down."

The number and location of the calls depend largely on individual tastes and requirements. The arrangement given here can be changed at will. It will certainly be desirable to have a call at the front door, the side door, the door to the bicycle room, and the door at the rear of the house to the kitchen. These four calls can be calculated on in all cases. We will place in the hall another button, which will be appreciated when it is desired to communicate with the kitchen, for, of course, it is intended to have the front-door button act on a bell in the hall at the same time it calls in the kitchen; under the table in the dining room will be placed a floor push that can be operated by the foot or by a combination consisting of a silk cord led to the table clamp and button; another button in the parlor will make 7 calls for the first floor. The second floor will have 4 calls, one in each bed room and one in the bathroom. This will be a total of 11 drops for the kitchen annunciator, which will have 12 drops, one unused, and it will be installed at the side of the locker at a height from the floor where the full face can be seen and where it can be reached easily to reset the drops. The push buttons will be set at points designated by the prospective occupants; but in the event of the placing of them being left to the judgment of the wireman, place the one in the parlor near the trim of the folding doors and the one in the hall in the trim of the outside door, both about 40 inches from the floor; place the buttons in the bed rooms in such a position that they can be reached with ease by a person unable to rise from the bed. The button in the bathroom should be placed at the side of the door, at the top of the wainscoting. The buttons for the outside should conform in material and design to the hardware used on the doors, and for the inside should be made of the same wood as the trim. In the hall is installed a 3-inch bell, connected in multiple with the hall drop. By this arrangement the bell will ring when the front-door button is closed; but as this is not desirable at night, we will install a small, neat switch at a convenient point under the bell and connect it in such a way that the bell can be cut out of circuit and the current diverted to a similar bell in the bed room of the servant. At night, the switch is set to ring the bell up stairs and in the day time to ring the one in the hall. In the front bed room, alongside of the button that calls in the kitchen, we will place a second button, to operate another bell in the servant's room, so that the mistress can call her during the night. It will be advisable to have these bells of different tones, to avoid confusion.

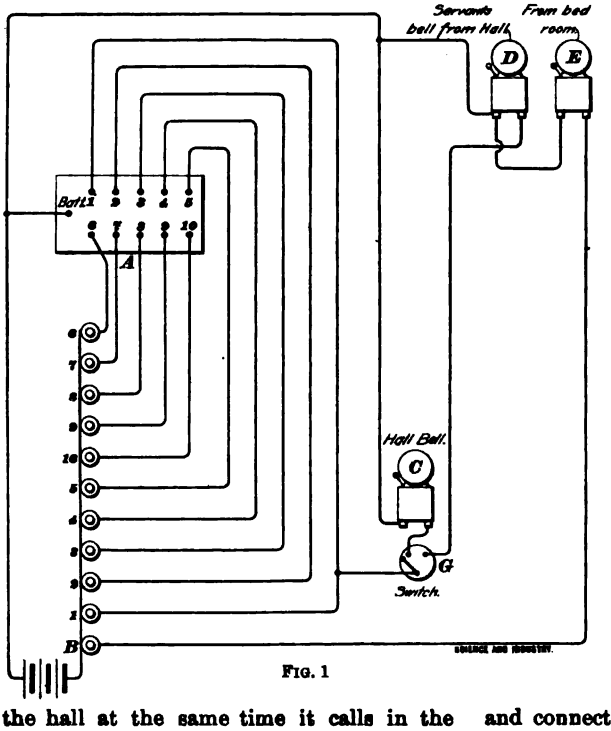

FIG. 1

Fig. 1 shows clearly the wiring and connections for the whole system: *A* is the connecting board of the annunciator, *D* and *E* the bells in the servant's room, *C* the hall bell, *G* the switch by which the bell is cut out and the current sent to the bell *D*, *B* the button in the bed room that operates bell *E*, and *1*, *2*, *3*, *4*, *5*, *6*, *7*, *8*, *9*, *10* are the other buttons.

Having completed the call system, we will

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now take up that of the burglar alarm. We can have every door and window indicate on a separate drop, but as it will be unnecessary to go to such an expense for so small a house as this, we will divide the floors into sections, each indicating on a separate drop. Section 1 will be the cellar, including all the doors and windows entering from the outside; section 2, the dining room windows; section 3, the front door only, for the reason that we will place a switch inside the door, to cut in and out the spring, so that members of the family can enter at night without giving an alarm and set the switch after getting in; section 4, the door to the bicycle room and the one at the head of the cellar stairs; section 5, the kitchen windows and the rear door and pantry window. On the second floor, section 1 will be the windows in the front bed room; section 2, the windows in the second bed room; section 3, the windows in the storage room and hall; section 4, the windows in the rear bathroom and rear bed room. The third floor will be 1 section, including all windows. We will require, for these sections, an annunciator with 11 indications, but will use one with 12, allowing one to remain blank. The sections are arranged with the idea that in case of an alarm the person answering will be called to a point from which he can command a view of every entrance protected by the section. We have assumed that the front chamber will be the one occupied by the owner, and on this assumption the annunciator for the burglar-alarm system will be set in the closet of this room.

Fig. 2 is a diagram of the wiring and connections for this system; *A* is the connecting board of the annunciator; *B*, *C*, *A*, *E*, *F*, *G*, *H*, *I*, and *J* are the window and door springs; *K* is the front-door spring, and *L* is the switch to control it. *B*, *B*, *B*, *B*, *B* connected form section 1, *C*, *C*, *C* form section 2, etc. It can be seen, by tracing the wires from the battery to the annunciator, which drop will fall by the closing of any button or spring, and therefore no further explanation will be necessary.

By recapitulation, we find that we will require the following material: 1 12-drop annunciator for the call system; 1 12-drop annunciator for the burglar system; 6 battery cells, 3 for each system; 2 3-inch bells, one for the hall and one for the servant's room; 1 sleigh bell for the servant's room; 1 2-point switch for the hall bell; 1 1-point switch for the hall door; 1 combination floor push for the dining room; 3 metal pushes for outside doors; 7 wood pushes for the several rooms; 50 pounds of wire; 7 door springs, 2 for the cellar, 2 for the front doors, 1 each for the bicycle room, kitchen, and hall door from the cellar; 60 window springs, 6 for the cellar, 20 for the first floor, 22 for the second floor, and 12 for the third floor; staples, tape, screws, nails, etc.

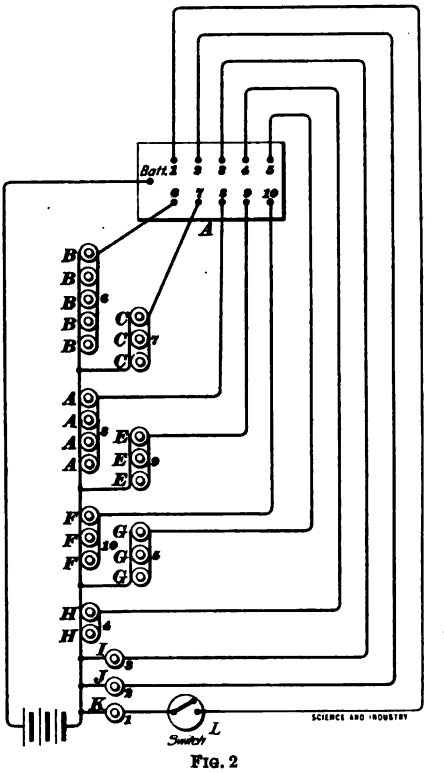

FIG. 2

The work will keep a man and helper busy for about 10 days. The cost will be from $100 to $125, which is probably one of the best expenditures of money that can be made on a house when the protection and convenience to the occupants is taken into consideration. These two systems, in connection with the light wiring by either of the two methods outlined in the previous articles on the subject, will give us a cottage in which the electrical work is complete and up to date.

In these articles the aim constantly kept in view has been to set forth the facts in such a manner that they will be of assistance to the prospective owner and builder in deciding what he wants and in seeing that he gets it, also to enable the wireman to

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give it to him. The measure of success in these particulars must, of necessity, be left to the judgment of the readers. The estimates of cost, in all articles, are necessarily only approximate, since they are based on the market prices of the day. The estimates of time are based on the experience of the writer. The idea, however, has not been to give absolute figures, but rather to give data as a basis for future calculations.

HIGH RAILROAD SPEED

Geo. E. Walsh

EXPERIMENTS FOR INCREASING THE RATE OF TRAVEL—SHEATHED TRAINS—FRICTION OF AIR ON A TRAIN

THE limit of railroad speed is something that the most conservative scientists and practical railroad men dare not predict. Since the powerful air-brakes and block signals have rendered the high speed of trains a comparatively safe means of ordinary traveling, a great amount of scientific ingenuity has been concentrated upon the problem of further increasing rapid transit without going outside of the bounds of safety. The many imaginative pictures and predictions of trains flying along on tracks overhead and underneath show the general interest aroused on this subject. The efforts made in this country and in England to acquire and hold the title to the fastest train in the world are productive of many new improvements and experiments.

One thing scientists and railroad men have practically agreed upon is that present speed has almost reached a limit under conditions that prevail on ordinary roads, and that not much higher records can be made without some special method of overcoming atmospheric resistance. A train moving at the rate of twenty or thirty miles an hour does not have very much atmospheric resistance to contend with, but after reaching a forty-mile limit this becomes a formidable factor in the problem. This has been most forcibly illustrated in recent times by the experiments with bicycles. A mile in two minutes is a good record for the unpaced bicyclist, but when following in the wake of a pacing machine the distance is covered in less than a minute and a third, and in the wake of a sheltering locomotive or car a mile has been covered in a trifle over fifty-seven seconds. So strong a factor does the atmospheric pressure prove that the pacing machines of the future will probably be provided with air shields, which will curve outward so as to protect the bicyclist from all gusts and outside currents of air.

SHEATHED TRAIN ON THE BALTIMORE AND OHIO RAILROAD

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FRONT VIEW OF THE SHEATHED TRAIN

Railroad men have been considering this same problem in trying to increase the speed of their fast express trains. Numerous illustrations have been made showing peculiar cigar-shaped engines and cars which would offer the least amount of friction to the air. But such inventions are not of practical value to ordinary railroads, where the rolling stock is all of a fixed type and cannot be radically changed except at a great expense.

A series of experiments are being conducted on the Baltimore and Ohio railroad that will probably help to throw new light on the difficult problem of atmospheric resistance. Some of the results so far obtained show that a remarkable increase in the speed of fast trains may be obtained on ordinary roads in the near future without materially changing the type or form of the rolling stock. The method is to remove all external obstructions from the train, and to sheathe every car and the engine so that a large percentage of the atmospheric resistance is removed. The roofs and ends of the cars are rounded, and the sheathing, instead of being perpendicular, runs lengthwise of the cars and from the roof down to within eight inches of the track, as shown in the accompanying illustrations. A smooth, continuous surface is thus offered to the wind and air, and the train moves through it with a minimum of friction.

According to the theory of the inventor of the sheathed trains, Mr. Frederick U. Adams, who is conducting the experiments on the Baltimore and Ohio tracks, the pressure of the atmosphere is the greatest resistance a train has to overcome at all velocities exceeding forty miles an hour, and this friction increases steadily as the square of the velocity. The train with which the experiments are being conducted runs between Baltimore and Washington, and its total weight is 325,000 pounds, exclusive of the engine and tender. While the roadbed is in first-class condition, there are many curves in the run, but in spite of this the speed of the train on the average promises to be increased from seven so ten miles an hour without any extra large locomotive. Heretofore railroad speed has been obtained only through the construction of larger and more powerful engines; but the sheathed trains seem to indicate that smaller engines and direct economy in the fuel will be the results of experiments now being carried out. Although considerable has been printed about modern fast trains, it is a noteworthy fact that the speed has not been increased more than four to six miles an hour in the past half century, and to double this increase by eliminating atmospheric resistance would be a remarkable achievement for Yankee brains and ingenuity.

The amount of friction the air offers to trains moving at a high rate of speed is tremendous, and can best be expressed in figures. At 40 miles an hour the pressure is 8 pounds to the square foot, at 75 miles an hour it is increased to 28 pounds, and at 100 miles it is 50 pounds. This means that an

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ordinary train of six cars offers about 600 square feet of resistance to the air, and at a speed of 60 miles an hour it would require a pull of 10,800 pounds on the part of the engine to overcome it. According to this the energy of the engine is largely absorbed in overcoming atmospheric resistance, and the higher the speed the more difficult becomes the labor. The new experiments are not conducted with the idea of eliminating atmospheric resistance, but to reduce it to a comparatively unimportant factor. If the experiments prove successful it is believed that on the same principle cars can be built so that the resisting surfaces will be reduced some 80 to 90 per cent.

WHEEL GUARDS

Constructor

SOME POINTS THAT SHOULD BE CONSIDERED IN THEIR DESIGN

HOW OFTEN have we observed, from some vantage point, the busy street beneath, surging with people and traffic. It is strange if at such a time we have not compared the black moving mass confined by the high banks of buildings on either side with a sluggish stream. The action, too, is that of flowing water, for where the cross streets intersect, there are eddies and counter-currents, and the change of direction is not accomplished straightway, but by easy turns.

As we use elbows and large bends in a pipe line to minimize the loss by friction, so we make the corner curb a quadrant of a circle having a considerable radius. Even then it will be noticed by those who are observant that the edge of the stone is ground and scarred by the wheels of trucks and wagons that time and again have come in collision with them.

The existence of a curb upon any street is for the purpose of preventing the encroachment of the roadway upon the pavement, and it acts as a bulwark or breakwater for buildings erected along the thoroughfare, and keeps the tide of traffic in its proper channel. Sometimes, as is frequently the case in the center of a city, there are streets, courts, or lanes that have been neglected by the city fathers to such an extent that they cannot boast of a pavement or curb of any kind, and in fact are too narrow in many cases to permit of such a convenience.

"THE APPEARANCE IS CERTAINLY NOT IMPROVED BY THE FURROWS AND GROOVES WHICH TIME AND THE WHEELS HAVE WROUGHT"

The corners of buildings located at the intersection of such streets are usually damaged considerably, being furrowed or broken by the iron hubs and tires of trucks and wagons as they swing around the sharp corners under the guidance of their reckless drivers. The stability of the building is, of course, little impaired, but the appearance is certainly not improved by the furrows

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"It Should Also Be Cut Away Sufficiently at the Top to Allow the Hubs of the Wheels to Clear It"

and grooves which time and the wheels have wrought. The corner of a brick or stone building chewed away in such a manner looks slovenly, having, as it does, the careless appearance of a dog-eared book or a shoe worn down at the heels, and it tells louder than words the disregard of some one, whether owner or architect, for the little details that make any building complete. The architect, in his practice of the profession, should look after just such small affairs as the guarding of unprotected corners liable to defacement, and to provide wheel guards of iron or stone for their protection. Almost any boulder or rock will do for a wheel guard when whitewashed and placed along a country road to guide some rustic swain or sleepy farmer between the fence posts of his lane.

Where the corner to be protected, however, is that of a building with architectural pretensions, some intelligence can well be spent upon the design of the guard. Since it stands out prominently from the building, it should be sturdy enough and sufficiently well bonded into the wall to withstand the heavy blows to which it is subjected. As it cannot usually be built in one piece, it should be divided to suit the courses of masonry or brickwork, and it should also be cut away sufficiently at the top to allow the hubs of the wheels to clear it when the tire of the wheel scrapes around the base. The height of the hubs being somewhat varied, care should be taken to design the stone for the lowest hub usual on the wheels of trucks or wagons. The wheel guard is not only applicable to the corners of buildings, but should be used in connection with all stone or brick gate posts and jambs of doorways through which necessity requires the passage of vehicles. They may be constructed of iron or stone, but should be in all cases very stoutly anchored. Driveways into stables are often provided with a curb, the jambs being set several feet away from the curb. In such cases it is not necessary to provide wheel guards, as the curb answers every purpose.

So it is that the smallest details about any building require consideration, and it is the attention the successful builder gives to these details that makes the building a credit to the designer and owner alike.

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THE CURVE OF ERRORS

George McC. Robson, M. A.

AN EASY METHOD OF SOLVING MATHEMATICAL PROBLEMS—APPLICATION TO PROBLEMS OF CONSTRUCTION AND OF COMPUTATION

THIS is the age of labor-saving machinery, and any invention that accomplishes satisfactory results with a minimum of labor is sure of a favorable reception. Among labor-saving devices, the graphical method of solving mathematical problems is entitled to a high place. The form of graphical solution which employs the curve of errors is at once so simple and so effective that it cannot fail to be useful to any person who can make a reasonably accurate drawing. The following examples will explain the use of the curve of errors.

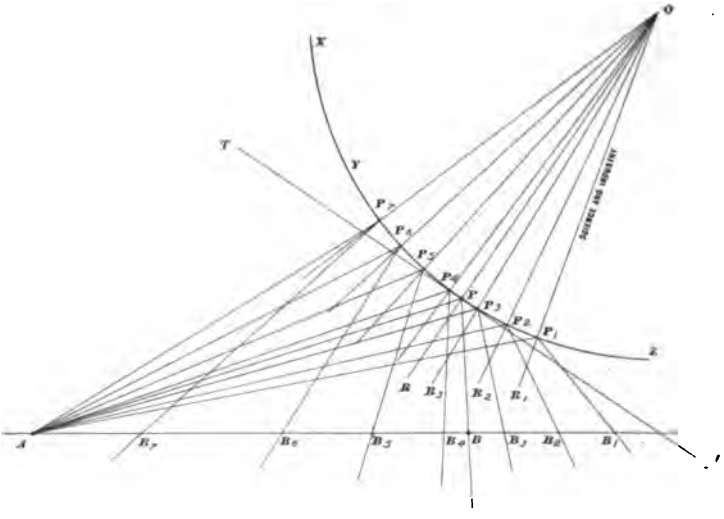

FIG. 1

We shall first apply this method to solve the following problem, recently sent in by a subscriber. In Fig. 1, $X\,Y\,Z$ is a given circle, and A and B are given points. It is required to find a point P on the circle such that the lines $A\,P$ and $B\,P$ shall be equally inclined to $T\,P\,T'$, the tangent at P; that is, it is required to draw $A\,P$ and $B\,P$ so that the angles $T\,P\,A$ and $B\,P\,T'$ shall be equal. This problem, which may be stated in a great many different ways, frequently presents itself in one or other of the following forms: (1) To describe an ellipse having two given points A and B for foci and touching externally a given circle $X\,Y\,Z$. This ellipse will touch the given circle at the point P in our subscriber's problem. (2) Being given two points outside of a convex spherical mirror, find a point P on the mirror such that a ray of light passing from A to P shall be reflected to B. Let $X\,Y\,Z$ (Fig. 1) be the section of the mirror made by the plane passing through A and B and through the center O of the mirror; then, P must lie on the circle $X\,Y\,Z$; hence this problem is the same as that of our subscriber.

Suppose the radius $O\,P$ to be drawn and produced to R; then evidently $P\,R$ bisects the angle $A\,P\,B$; hence the problem is to find the point P such that the radius $O\,P$ produced shall bisect the angle $A\,P\,B$.

Take any point P_1 on the given circle; draw $A\,P_1$; draw the radius $O\,P_1$, and produce it to R_1. Draw the line $P_1\,B_1$ cutting $A\,B$ in B_1 and such that the angles $A\,P_1\,R_1$ and $R_1\,P_1\,B_1$ are equal. If B_1 coincides with B the problem is solved; if B_1 does not coincide with B, the error in the length $A\,B_1$ is equal to the distance $B\,B_1$ which is the difference between $A\,B_1$ and $A\,B$. This error is regarded as *positive* or *negative* according as $A\,B_1$ is greater or less than $A\,B$. Take any other points P_2, P_3, etc. on the circle; draw the lines $A\,P_2$, $A\,P_3$, etc., and draw the lines $P_2\,B_2$, $P_3\,B_3$, etc. in the same manner as $P_1\,B_1$ was drawn. If any of the points B_2, B_3, etc. coincides with B the problem is solved; if not, proceed as follows:

In Fig. 2, draw any base line $Q\,X$; on $Q\,X$ take $Q\,G_1 = A\,P_1$, $Q\,G_2 = A\,P_2$, $Q\,G_3 = A\,P_3$, etc. Through the points G_1, G_2, G_3, etc. draw perpendiculars to the base line $Q\,X$.

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On these perpendiculars lay off $G_1 D_1 = B B_1$, $G_2 D_2 = B B_2$, $G_3 D_3 = B B_3$, etc. Thus, each of the perpendiculars $G_1 D_1$, $G_2 D_2$, $G_3 D_3$, etc. is equal to the corresponding error in Fig. 1. The perpendiculars $G_1 D_1$, $G_2 D_2$, $G_3 D_3$, etc. are called the *ordinates*. When the error is *positive*, the ordinate is drawn *upward;* and the ordinate is drawn *downward* when the error is *negative*. Now draw a smooth curve through the points D_1, D_2, D_3, D_4, D_5, D_6, and D_7; this is called the *curve of errors*. Let the curve of errors cut the base line $Q X$ in the point G; then, $Q G$ is equal to the required line $A P$. A circle with A as center and radius equal to $Q G$ cuts the given circle $X Y Z$ in the required point P. The circle with A as center and radius equal to $Q G$ will generally cut the given circle in two points, but usually only one of these points gives a solution of the problem. In Fig. 1, the point B lies between B_3 and B_4, and consequently P must lie between P_3 and P_4; in this case, therefore, only one of the intersections of the circle whose center is A with the given circle gives a solution of the problem.

The preceding is a good example of the application of the curve of errors to a problem of construction; we shall now give an example of the use of the curve of errors in a problem of computation.

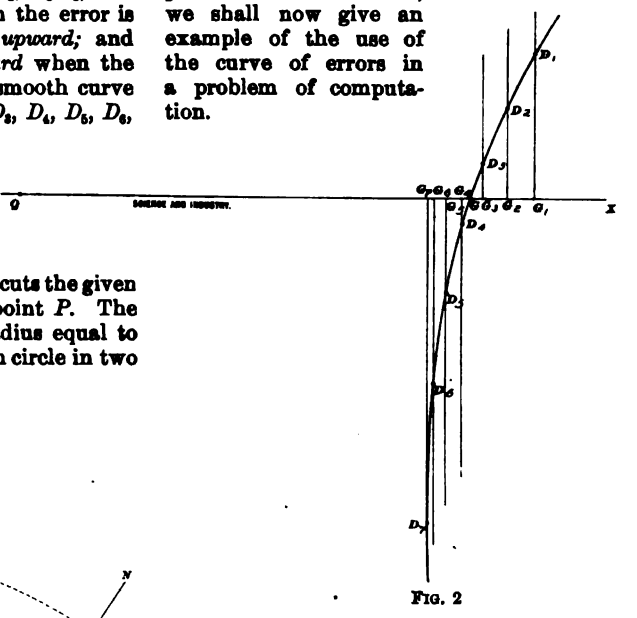

FIG. 2

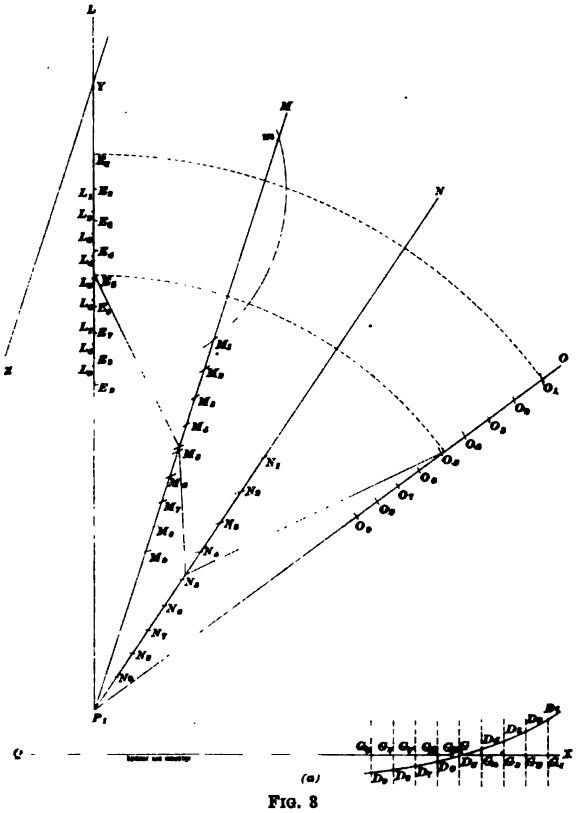

FIG. 3

The lengths of the lines $B C$, $C A$, and $A B$ (Fig. 4) are known. From any point P, which may or may not be in the plane $A B C$, the angles $B P C$, $C P A$, and $A P B$ are observed. It is known that the angles $A B P$ and $B C P$ are obtuse and that the angle $C A P$ is acute. It is required to find the lengths of the lines $P A$, $P B$, and $P C$. If P is in the plane $A B C$, the sum of the three observed angles will be 360°, or the sum of two of them will be equal to the third. The following construction is for the case in which P does not lie in the plane $A B C$, but is easily modified to suit the case in which P is in the plane $A B C$.

Take any point P_1 (Fig. 3) and lay off the angles $L P_1 M$, $M P_1 N$, and $N P_1 O$, respectively, equal to the observed angles $A P B$, $B P C$, and $C P A$. Draw $Y Z$ parallel to $P_1 M$ and at a distance from it equal to the given line $A B$. Take any point L_1 between P_1 and Y, and assume that $P_1 L_1$ is equal to $P A$. With L_1 as center and radius equal to

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$A\,B$, describe a circle. Since L_1 was taken between P_1 and Y, this circle will cut the line $P_1\,M$ in two points M_1 and m, and either $P_1\,M_1$ or $P_1\,m$ should be equal to $P\,B$. Since the angle $A\,B\,P$ is obtuse, we must

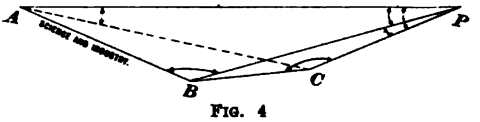

FIG. 4

assume that $P_1\,M_1$ is equal to $P\,B$. With M_1 as center and radius equal to $B\,C$, describe a circle cutting the line $P_1\,N$ in two points, of which N_1 is the nearer to P_1. Then $P_1\,N_1$ should be equal to $P\,C$. With N_1 as center and radius equal to $C\,A$, describe a circle cutting $P_1\,O$ in two points, of which O_1 is the more remote from P_1 (we take the point more remote from P_1 because the angle $C\,A\,P$ is acute). Then, $P_1\,O_1$ should be equal to $P\,A$, and therefore $P_1\,O_1$ should be equal to $P_1\,L_1$. With P_1 as center and radius equal to $P_1\,O_1$, describe an arc of a circle cutting $P_1\,L$ in E_1. If $P_1\,O_1$ were equal to $P\,A$ and to $P_1\,L_1$, the point E_1 would coincide with the point L_1. Hence, $L_1\,E_1$ is the error due to the assumption that $P_1\,L_1$ is equal to $P\,A$; this error is positive because L_1 lies between P_1 and E_1; the error would be negative if E_1 lay between P_1 and L_1. Taking other points L_2, L_3, etc. on $P_1\,L$ we get the corresponding errors $L_2\,E_2$, $L_3\,E_3$, etc.; when none of the angles $A\,B\,P$, $B\,C\,P$, and $C\,A\,P$ is nearly equal to a right angle, we can easily choose the points L_2, L_3, etc. so that some of the errors shall be positive and some negative. Take any base line $Q\,X$ [Fig. 3 (a)]; lay off $Q\,G_1$, $Q\,G_2$, $Q\,G_3$, etc. equal to $P_1\,L_1$, $P_2\,L_2$, $P_3\,L_3$, etc.; lay off the ordinates $G_1\,D_1$, $G_2\,D_2$, $G_3\,D_3$, etc., respectively, equal to the errors $L_1\,E_1$, $L_2\,E_2$, $L_3\,E_3$, etc., being careful to draw the ordinate *upward* for a *positive* error, and *downward* for a *negative* error. Draw the curve of errors through the points D_1, D_2, D_3, etc., and let it cut the base line in the point G. Then, $Q\,G$ is equal to $P\,A$, and the length of $P\,A$ can be found by measuring $Q\,G$. When the length of $P\,A$ is known, the lengths of $P\,B$ and $P\,C$ are easily found by the construction used to determine the points M_1 and N_1 in Fig. 4.

If one of the angles $A\,B\,P$, $B\,C\,P$, and $C\,A\,P$ is a right angle it is impossible to make a construction giving a negative error; in this case the curve of errors approaches the base line and touches it at the point G, as shown in Fig. 5, but the curve does not cut the axis. If any of the angles $A\,B\,P$, $B\,C\,P$, and $C\,A\,P$ is nearly a right angle, it requires fine drawing to get a negative error; in this case, as in the case in which one of these angles is exactly a right angle, the point G is found from the positive errors alone by producing the curve of errors to cut the base line.

Theoretically, it is possible to determine as many points as we please on the curve of errors; and the greater the number of points determined, the greater should be the accuracy of the result. In practice, however, it is not advisable to determine a very large number of points on the curve of errors, for this requires a correspondingly large number of lines in the figures, and when the

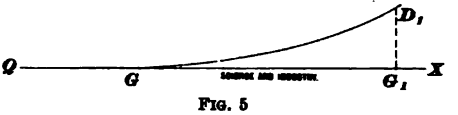

FIG. 5

figures become crowded with lines it is difficult to determine their intersections exactly. It is frequently possible to obtain two constructions which give nearly equal and comparatively small errors of which the one is positive and the other negative; in such cases a good result is usually obtained by locating the two corresponding points on the curve of errors, and taking the straight line joining these points to be the curve of errors.

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STEAM PIPE FITTING

Chas. J. Mason

THE TOOLS USED IN STEAM FITTING—FITTINGS AND THEIR USES—METHODS AND SUGGESTIONS FOR DOING WORK

EVERY steam plant should be equipped with a full set of pipe-fitting tools, and every engineer should have a knowledge of the use of these tools, as the opportunities for their employment will be many. There is nearly always a necessity for renewing some portion of the piping in a plant, and as time goes on new conditions call for changes in the original piping. While the engineer in charge may not have to do this work himself, he may be called on to design or superintend the work, but even if he is not he should be thoroughly qualified to oversee the details from the beginning of the work to its completion and to make the minor changes and such repairs as a new joint, replacing a leaky nipple, moving a radiator or other apparatus, etc.

It is the intention to place before the readers a few of the more important points concerning pipe fitting, more especially those that will be of service in such jobbing and bench work as engineers should be familiar with. As the article has been written for the benefit of those inexperienced in this line of work, it is probable that the good pipe fitter will find nothing new in it.

The tools used in pipe fitting are few, compared with those used in some of the allied trades in the engineering profession. A pipe-fitter's box is equipped with a number of *similar* rather than different *kinds* of tools. It must not be thought that the skill and judgment called for is in proportion to the kinds and character of the tools employed, for in the pipe-fitting trade as well as in any other there are certain principles to be understood, certain facts to be learned, and certain methods to be employed to produce the desired results. Any trade is easily learned by an apt scholar who uses his reasoning faculties and makes a study of cause and effect. The mechanical effort is an incident rather than the principal equipment in any trade or occupation. As a proof of the truth of this statement, we may cite the case of a man filing a piece of metal in a vise. Every machinist knows from his earliest experience that it is a hard task to file a surface "straight." It is only after months of constant practice at this particular work that he can accomplish the desired result. His every movement is guided by the intellect and the sense of touch that can be acquired only by actually doing that particular thing for a certain period of time. Now, this period of time is not always the same for all men, as some become proficient earlier than others. It may be stated without fear of contradiction that the man who gives the problem some intellectual consideration will the earlier learn the art of properly handling a file, and for this reason the mechanical movements are secondary, although important.

A thinking man will readily see that in order to file a surface true and straight, his arms must act as parallel levers, so to speak. This is almost impossible to accomplish, but he learns that the circular movement that his arms give to the file can be compensated for by choosing a file with a "belly" to it—in other words, one that is slightly bent—and using the convex side to file with. He will further find that by changing the direction of the file occasionally he will not only make the work easier, but his imperfections will be truly shown up by the appearance of the surface he is working on. Such practice as this, as the result of thought, cannot but make a man expert in the shortest possible time.

The above is only one of the many examples that might be cited to prove that *thought* is the *principal* factor in any mechanical work.

But to return to our subject: The tools used in pipe fitting are as follows: A pipe vise; two or three sizes of stocks with the accompanying dies for cutting the threads on the various pipes; pipe cutters that can take in all the sizes of pipe from ¼-inch to 2½-inch (pipes larger than 2½-inch are usually cut and threaded in a pipe machine); various sizes of Stillson wrenches, from 6-inch to 48-inch; chain pipe wrenches, or tongs, as they are sometimes called, which are used on the larger sizes of pipe; a full set of pipe taps, with single and double-ended wrenches to suit each tap; several sizes of monkey wrenches; and chisels, chisel

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bars, hand hammers and sledge hammers. One other instrument yet remains to be spoken of—a nipple holder, and while this is simply a piece of pipe with a coupling screwed on, it is nevertheless a tool; and

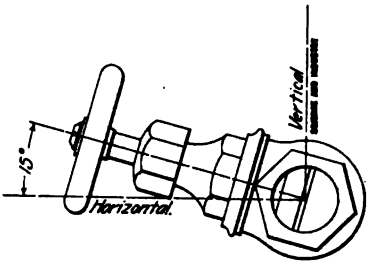

FIG. 1

last but not least, we can add a squirt oil can and a plumbago (graphite) pot and brush.

None of the tools mentioned require any extensive description. There are several makes of pipe dies in use, but they are essentially of two kinds: the solid die, which will cut a standard size, and the adjustable die, which will cut a thread to suit any fitting of the same nominal size and number of threads per inch. In passing, it might not be out of place to suggest to engineers the desirability of familiarizing themselves with the pitch of the different threads used in pipe fitting. How many of them know and can tell offhand how many threads per inch a ¼-inch pipe tap contains? It is not absolutely necessary that a man should know the pitch of threads in order to turn out good work, nor would he tap a hole any better if he did know them, but we are inclined to have more confidence in a man who knows what his tools are as well as what they can do.

As a nipple holder is a home-made tool, a description of how to make one will not be out of place. *Close nipples*, as they are called, are frequently required in steam plants, and they can be procured at a supply store, but in an emergency it may become necessary to make one. It can readily be seen that it is impossible to cut a *close* nipple using only the die and stock, because of the space occupied by them and the length of pipe. A nipple holder permits a very short nipple to be made.

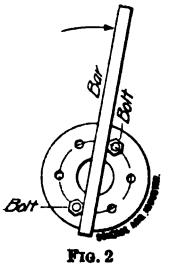

FIG. 2

Let us assume that a close ¼-inch nipple is required. This will be from 1½ to 2 inches long, and we will require a holder to make it in. Take a piece of ¼-inch iron pipe, say from 8 to 10 inches long, cut a thread on one end of it, and then file this end flat and square with the center line of the pipe, just as though it had been faced in a lathe. Now take a ¼-inch coupling (not a union) and screw it on the pipe as tight as possible without straining the threads. The unoccupied thread in the coupling is more than sufficient to admit of the pipe from which the nipple is to be cut being screwed in so that it will bear tight against the filed end of the first pipe. It will usually be found necessary to cut off a piece of the projecting coupling, which can be done with a hack saw, and the holder will then be ready for use.

The nipple itself is made from as short a piece of pipe as can be cut in the vise. A thread is cut in the ordinary manner on the end of this pipe, which is then screwed into this nipple holder until it "brings up" against the pipe in the coupling, when the nipple can be cut to the required length, the holder being gripped in the vise. I advocate the use of the hack saw instead of the regular pipe cutter for this purpose, especially on the smaller pieces of pipe. The die may be entered on the pipe—or, rather, nipple now—placing in the die stocks a guide bushing that will easily ride over the coupling, which will be one size larger than that for the pipe. The thread can now be cut until the die just touches the coupling, and there will be practically no blank space between the threads on the ends. After the die has been backed off the nipple can be removed from the holder by unscrewing it with a Stillson wrench. A nipple holder should be made for each size of pipe that is cut and threaded by hand.

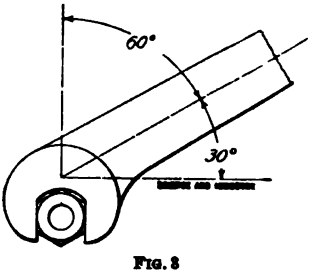

FIG. 3

The other tools mentioned require no description, and we can now consider some of the methods employed in pipe work in the steam plant.

In order to obtain a smooth and clean thread on a piece of pipe it has been found that lard oil must be used to lubricate the

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die, especially if the die is much worn; without it, a decidedly ragged thread will result. It will be necessary, however, to thoroughly wipe off the lard oil after the thread has been cut, for this oil carbonizes under heat, and it

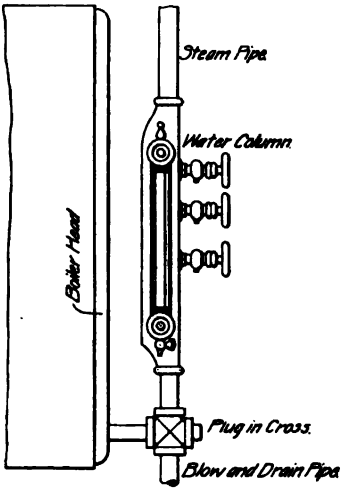

FIG. 4

would then be impossible to disconnect the pipe on which it was used. Some time ago red and white lead mixed into a light putty was used when it was the intention that the pipes should not be taken apart again. Red lead makes a joint that seldom, if ever, leaks, but it is possible to make a connection with a mixture that will not set hard and fast.

A paste of cylinder oil and plumbago is an excellent mixture to apply to the threads of pipes and fittings. If the threads have been properly cut, there will be no need to depend on the mixture for a tight joint, and it will be found much more satisfactory to be able to remove a pipe or fixture without being obliged to smash an elbow or tee. It will also be found a convenience to screw joints with the smallest wrenches that can be used, as an opportunity is thus afforded to use larger sizes in unscrewing them.

In making up a piece of piping in which several fittings are quite close together, tighten each fitting by itself; do not follow the common practice of making them up loosely at first and then tightening all together by applying the wrench to the fitting the farthest from the main connection, as this does not insure tight joints and the intermediate fittings, nipples, etc., are unnecessarily subjected to a torsional strain. For the same reason, when connecting a globe valve to a pipe, apply the wrench to the hexagonal part nearest the pipe.

While speaking of valves, it will be well to mention one or two other interesting points about them. It is sometimes impossible to make a tight joint between the iron pipe and the valve. This may be due to a defective thread in the valve or pipe or in both, or it may be due to the fact that the brass of which the valve is composed expands more than the iron in the pipe. The writer has met with success in overcoming this trouble by heating the valve and then screwing it on the cold pipe, using a paste of graphite and cylinder oil. This method may be tried after it has been found impossible to otherwise make a tight joint.

The better kind of valves usually have removable disks. When it becomes necessary to renew a disk, the bonnet must be taken out first. In replacing the bonnet, tighten it only sufficient to prevent leakage, for it may be found necessary to remove it again sometime in the future and it may then be done without marring it or twisting the hexagon out of shape.

A few moments devoted to a consideration of the different fittings used in piping and their relative positions in a line of pipe will not be wasted. The names of the fittings are as follows: Elbows; forty-fives (45°); tees; plugs; caps; reducers (or bushings); nipples; valves; unions (with ground, perishable, and flange joints); couplings (reducing and right and left); crosses; special fittings, such as elbows and tees of a nominal size reduced at some point to a smaller size to avoid the use of reducers; angle, check, and gate valves, and plug cocks; locknuts.

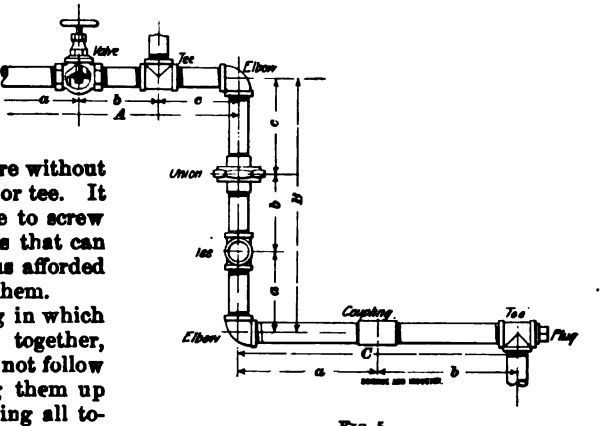

FIG. 5

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Elbows and tees are used for changing the direction of run of a line of pipe. Tees are used for the purpose of running a branch from the main pipe, and they are sometimes used instead of elbows by inserting a plug in the unused opening, which admits of a branch being run at some future time should conditions demand it. Of course, it is assumed that the main will be of sufficient size to meet all possible future demands. A plugged tee is also preferable to an elbow in the smaller sizes of water pipe, because the pipe can more readily be cleaned out. Caps are screwed on the end of a pipe for the purpose of closing the end; should there be a fitting of any kind at the end, a plug may be used to close the outlet. Reducers, as the name implies, serve to reduce the piping to the required size; they have an outside thread to suit a fitting, and an inside thread for a smaller pipe. Nipples are short pieces of pipe threaded on both ends, and they are used to make a close connection between fittings or valves in places where space is limited. The method of making nipples has already been described.

Valves require no special description. In general, it is desirable to have a valve at each end of a pipe, for in some cases it is necessary to shut off steam from both directions, as for instance when the piping between two tanks gives out. By closing both valves the entire pipe can be taken away without disturbing the tanks. There are cases where more than two valves are required, but two is the least number that should be installed.

Globe valves in horizontal pipes should be placed so that the stems make an angle of about 15 to 20 degrees with the horizontal plane, as shown in Fig. 1; this is done so that the water of condensation may flow unimpeded in the desired direction. Valves are usually placed so that the stems are upright, which, of course, looks better, but looks should be sacrificed for the more important consideration referred to. If the reader will remove the bonnet from a globe valve he will see that the position suggested will be the nearest approach to that required for the object in view. Strictly speaking, the best position for the stem is exactly horizontal, but the conditions must govern in this matter. Water will leak more readily than steam from the stuffingbox of the valve, and it is for this reason only that I suggest the valve stem be set at about 20 degrees, or at least so that the gland nut is above the possible water line in the pipe. Another well-known fact that will bear repetition is that the valve should be connected so that it will close against pressure; in that case the stem may be repacked while the pipe line is under pressure.

There are three kinds of unions: those with ground joints, perishable joints, and flange joints. The ground-joint union is made of brass; it is the most expensive, but it is also the most convenient. The perishable-joint union (which is of the same design externally as the one first mentioned) I consider a nuisance, and mention it only because it is in existence. The flange joint makes a good job when properly made up. The flanges should be faced to receive the jointing material between them, and I would suggest, when time and circumstances permit, scoring with a V tool the face of each flange with one or two small grooves into which the jointing will be squeezed and so prevent a possible blow-out.

Flanges are screwed on pipes by using a bar and two bolts or pins in the bolt holes, as shown in Fig. 2. The first procedure when cutting the jointing material which is to be placed between the flanges is to cut out the center; if this is done the possibility of making a "blind joint" will be very remote. Even old and experienced steam fitters and engineers sometimes forget this important point. The bolt holes may be cut out next; they should be a little larger than those in the flanges, so that the bolts may enter easily in case of any inequalities. In making a joint of this kind in close quarters where the pipes do not meet evenly and trouble is likely to be experienced, I would advise using bolts a size smaller than those originally intended. It is much better to use hexagon nuts than the square ones usually furnished, because they present a better appearance and in limited space a wrench can be used to better advantage in tightening them. It has been found that a wrench with an offset of 30 degrees (see Fig. 3) is the most efficient. By alternately changing the wrench from the 30- to the 60-degree angle, the greatest number of moves of the nut can be obtained.

Couplings are simply connections between lengths of pipe. This is their sole function, except possibly when the "right and left" kind are used as unions. Aside from the question of cost, it is desirable to have more unions and fewer couplings in a pipe system.

Crosses are used where two outlets from a main are required to be opposite to each other, and at a right angle to the main.

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Another use for the cross is shown in Fig. 4, in connection with a boiler water column. Its superiority over the tee frequently used here lies in the fact that a plug inserted in the unused opening can be removed to clean out the pipe when occasion requires.

Special fittings are made to meet the requirements of conditions and surroundings. They are articles of convenience and symmetry more than of necessity. This is not said to discourage their use, but rather to encourage the installment of reasonable apparatus that will be both useful and ornamental. There are many places, for instance, where the use of a 45-degree fitting will present a better appearance than an elbow and at the same time offer less resistance to flow than an elbow, but in spite of these facts elbows are more generally used.

Angle valves also serve as elbows, thereby dispensing with those fittings. Check-valves are used to admit the feedwater, and they also prevent its return. They are usually placed near the boiler, between the feed pump or its equivalent and a globe or similar valve. It is placed in this position because of the importance of being able to disconnect the check-valve while the boiler is in operation. Gate valves differ from the flat or conical-seated globe valves in that there is an unrestricted flow through the former when they are wide open. Each has its advantages, and both are widely used. Ordinary plug cocks are a nuisance, because it is always hard to keep them tight, and if they are used much it becomes almost an impossibility. The only place where an ordinary plug cock can be used to advantage is in the pipes connecting to the dial gauges; here they present a neater appearance than a valve would, and as it is not necessary to open and close them continually, they remain tight a long time.

Locknuts are used on pipes threaded for a greater distance than is required for ordinary fittings. It would not be safe, in putting a feed pipe in a boiler, to screw the pipe into a plate that was thin from wear, corrosion, or otherwise; the pipe is then screwed in until it extends through the plate and a locknut is placed on the inside and one on the outside. If locknuts cannot be readily purchased, the hexagon ends of an old globe valve may be sawed off and used for the purpose. The joint between the nut and the boiler plate may be made tight by winding a piece of twine or lampwick soaked in red-lead paint around the pipe close to the plate before the nut is screwed up tight against it.

All the fittings in the pipe system of a plant should be of the best quality, and the piping should be extra heavy to stand the test of time and usage. Water pipes, when of commercial wrought iron, should be galvanized. In laying out a line of piping or in replacing a portion of an existing line, the measurements should be taken from center to center of the various fittings; the allowance for the threaded part of the pipe can be made after the center-to-center and overall measurements have been made and before the pipe is cut. The worker will know from experience just what to allow for the threaded part on different sizes of pipe. Fig. 5 gives an illustration of how the measurements on a pipe system are made, and will serve as a suggestion.

THE MICROBE CRAZE

PROFESSOR NORTON says: There is great danger of the bacteriological craze landing its devotees in a quagmire from which extrication will be difficult if not impossible without loss of prestige. The earnest investigators are prone, in their enthusiasm, to take too much for granted (the wish being father to the thought), and it will not be at all surprising to find that many steps will have to be retraced and many ingenious and promising theories abandoned. It should be borne in mind that microscopic life is, in the main, beneficent to humanity; that the varieties associated with disease are comparatively few, by comparison with the others; and that in the case of the bacteria definitely identified with specific diseases, it has never been satisfactorily demonstrated that they are the cause, and not the product, in such cases. Although some facts are positively known in bacteriology, yet the conclusions drawn from them are mainly conjectural, and it is not at all unlikely that the next generation will see the present teachings thrown out, and a general recasting of theories.—Popular Science News.

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CONSTRUCTING A SHEET-METAL CUPOLA

(*Continued from the December, 1900, Number*)

William Neubecker

Developing, Forming, and Laying the Metallic Covering of the Dome

WE MAY now assume that the framer has sheathed the dome, placing the wooden ribs in position as shown in Fig. 32, and it remains for the sheet-metal worker to get out and lay the metallic covering. Patterns for the several sections of the dome must first be obtained, after which 31 duplicates will be required to cover the entire surface.

Fig. 32 shows an elevation of the dome, in which *A*, *B*, *C*, and *D* designate the spaces between the ribs making up the surface of the dome. In order to lay out the patterns for these spaces, draw a center line through the section *A*, as shown by *E F* in Fig. 32; divide this line into equal spaces as designated by the horizontal lines *a b*, *c d*, *e f*, *g h*, *i j*, and *k l*. These lines form the basis of measurements for the patterns. In order to lay out the patterns, draw any vertical line on a sheet of metal and divide it into equal lengths, to correspond to the divisions laid out on the line *E F* in Fig. 32. Through these divisions draw horizontal lines as shown in Fig. 33 at *a b*, *c d*, *e f*, etc., making them equal to the corresponding lines in Fig. 32. Through these lines trace the irregular curve as represented, adding the necessary laps of 1 inch upon each side. The pattern *A B C H* thus obtained will be the necessary covering for the spaces marked *C* and *D* in Fig 32; sixteen pieces of this pattern will be required. The pattern for the pieces at the corner of the octagon will not be cut square at the lower end, but on an angle, as shown by the shaded portion at *D*, Fig. 33. There will, consequently, be required sixteen pieces of metal cut from the pattern *A B C D*, eight being used right-handed and an equal number left-handed. The right-hand piece is shown at *A*, Fig. 32. The laps are now bent up with the pliers and stretched with the stretching hammer and stake, in order to give them the necessary convex form of the dome. They are also drawn inward and allowed to buckle somewhat, for the concave portion of the dome. These sections, having been stretched and buckled to the proper shape, are placed in position between the wooden ribs as shown in Fig. 32, and the

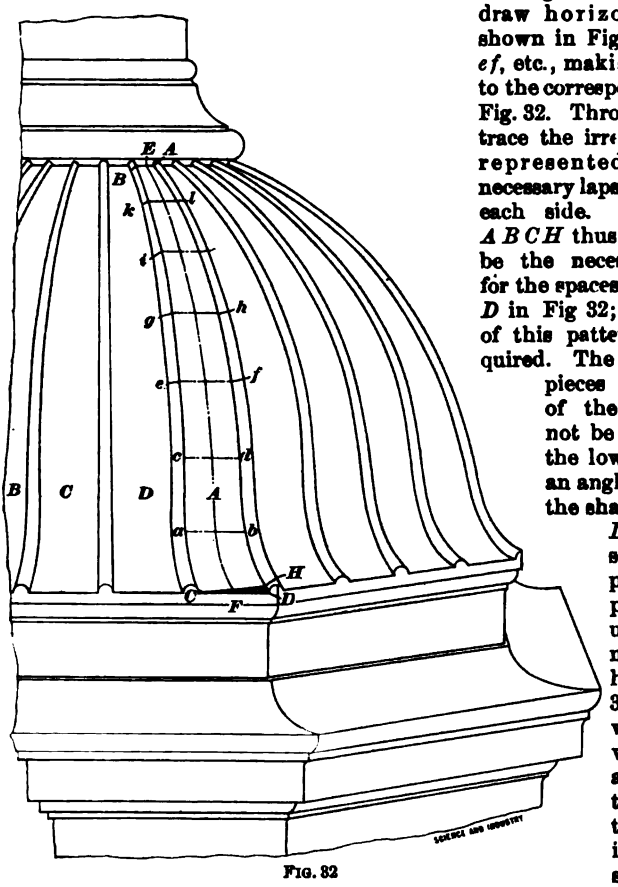

Fig. 32

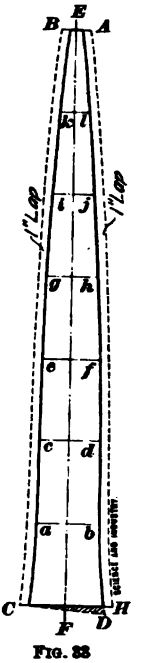

Fig. 33

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1-inch laps well dressed against the ribs and nailed. The laps on the sheets where they fit the concave portion of the dome are dressed until they are flat or overlapped. At the top of the dome, as shown at *M* in Fig. 2, a flashing is placed around the entire circumference, over which the lantern *N* is set, while at the bottom the sheet-metal covering of the dome is soldered to the 2-inch lap of the main cornice.

The metal ribs can be made either of sheet metal or sheet lead. If the job is of galva-

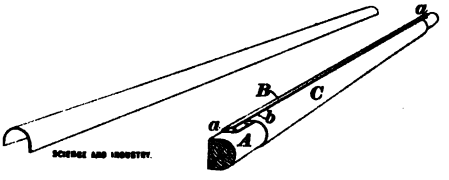

FIG. 34

nized iron, use sheet lead, as it is pliable and works itself firmly over the wooden ridges. If the job is of copper, make the ribs of 18-ounce soft copper. Should it be necessary to make the ribs of galvanized iron or copper, they are either hammered by machine or can be made by hand; both methods will be fully described in connection with the hand and hammer work for the lantern *N* shown in Fig. 2. Assuming that lead will be used for the ribs, take a

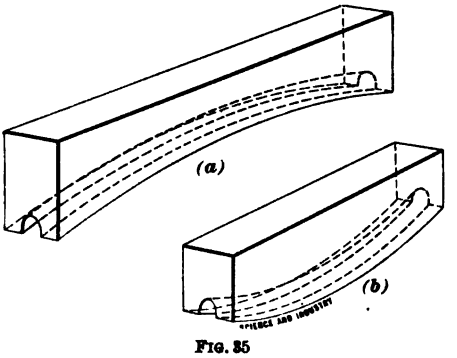

FIG. 35

stretchout of the material necessary to cover the rib, and the number of feet in length required, making them of material four feet in length. Bend these pieces of metal as shown to the left in Fig. 34, which may be accomplished as designated in the right-hand portion of the same figure where *A* is a straight piece of wood cut to the semicircular form of the rib, and *B* a metal edge nailed to the wood and turned as at *a a*. The sheet lead for the covering of the rib is placed in the groove *b* and then turned over the wooden form. In order to give the metal covering for the ribs the required bends lengthwise, two wooden forms will be required, one as shown at (*a*) and the other

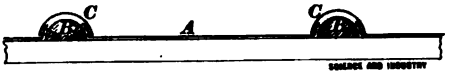

FIG. 36

as at (*b*), Fig. 35. The form at (*a*) is used for the upper portion of the rib while (*b*) is required to form the lower portion. After all of the metallic ribs are formed in this manner, they are put over the wooden rib, as indicated at *C*, *C* in Fig. 36, and nailed as shown with 1-inch galvanized wire nails, or secured with wood screws and lead washers. Care should be taken not to drive the nails too close to the roof line, or a leak will occur. As the dome is concave and convex, it is necessary, in placing the metallic covering on the ribs, to start at the bottom, or concave portion, and work the lead over the wooden ribs by means of the dies (*a*) and (*b*), Fig. 35. These dies are made of maple, hav-

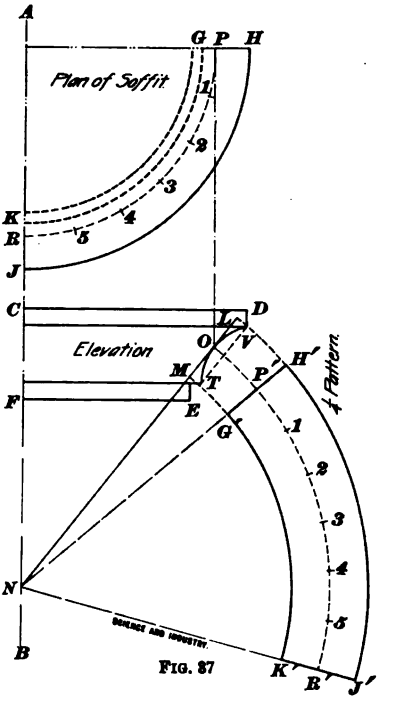

FIG. 37

ing the required sweep to fit the curves of the dome, the profile of the rib being gouged out as shown. It is necessary in getting out these dies to see that sufficient play is left

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for the lead or copper sheet between the groove in the die and the rib.

The next feature in the construction of the cupola which requires attention is the lantern *N* shown from *b'* to *c'* in Fig. 2. This is all circular work, and can either be done by hand or by machine. Although the

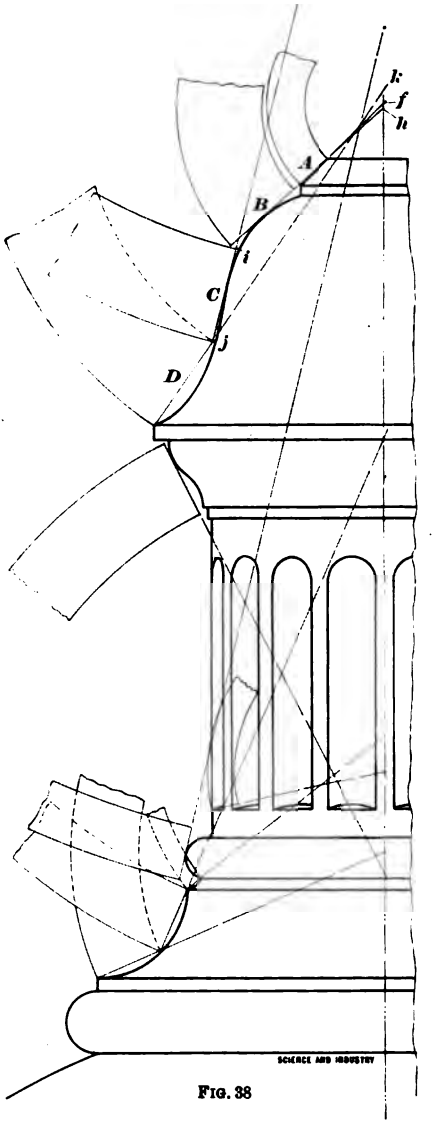

FIG. 38

machine work is the most modern method, some small shops are not equipped with the necessary machinery, and if work of this character comes to them it will be necessary to turn it out by hand. It is first required to draw a full-size detail of the half elevation of the lantern. This drawing is shown in Fig. 38, and is laid out in the usual manner. As the roof of the lantern shown at *A B C D* is to be made by hand in any case, it is well to get out the pattern for this portion first. When developing the blanks for the curved moldings which are to be raised by hand, care should be taken to obtain the correct amount of iron or other metal required, so that when the ends of the patterns are riveted together and hammered to their true profile, the diameters of the top and bottom will be of the size first determined upon. Fig. 37 is the development of a cove molding, and the principles therein shown should be applied to any form of mold raised by hand. This figure shows the plan and elevation of a molding formed by stretching, in which *A B* is the center line, *C D E F* the elevation, and *G H J K* the plan. Care should be taken when averaging the cover *T V* to draw the line *L N* at such an angle that the mold can be stretched or raised with the least amount of work. To average the mold shown in Fig. 37 so that it may be worked to the best advantage, connect the extreme ends of the cove by the dotted line *T V*, and bisect the cove, thus obtaining the point *O*. Through this point draw the line *L M* parallel to *T V*

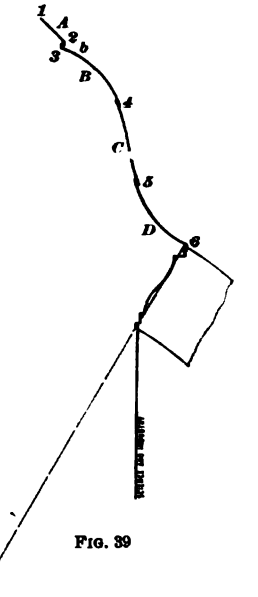

FIG. 39

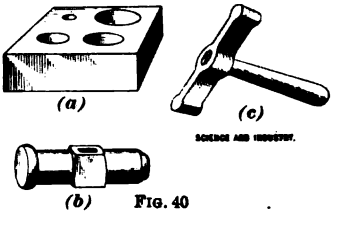

FIG. 40

extending it until it intersects the center line *A B* at *N*. From the point *O* lay off on the line *L M* the stretchout of the two halves

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of the cove *O T* and *O V*, as shown by *O M* and *O L*. When stretching the metal blank, the point *O* remains stationary while *L* and *M* will be stretched until they meet at *V* and *T*, the amount of hammering required being equal on both sides. From the point *O* in the elevation draw the line *O P* parallel to *A B* until it intersects the line *A H* in plan at *P*. With *A* as a center and *A P* as a radius, describe the arc *P R*, dividing it into equal spaces, as shown from *1* to *5*. With the point *N* in the elevation as a center, and radii equal to *N M* and *N L*, describe arcs *L J'* and *M K'*. From *N* draw any line, as *N H'*, cutting the two arcs just drawn at *G' H'*. With *N* as a center and *N O* as a radius, describe the dotted arc *O R'*, cutting the radial line *N H'* at *P'*. Measuring from *P'*, set off six spaces equal to the six spaces shown on the corresponding line in the plan, as designated from *P'* to *R'* in the pattern. From *R'* just obtained, draw a line to the center *N*, cutting the inner arc at *K'*, and extend the line until it cuts the outer arc at *J'*. Then will *G' H' J' K'* be the one-quarter pattern for the cove molding.

The foregoing rule is applicable to all shapes and molds, and the method is used for determining all of the patterns required for the moldings in Fig. 38. In order to make this method clear, the development for the blanks *A*, *B*, *C*, and *D* in Fig. 38 will be laid out. In order to develop the blank *A* in Fig. 38, extend the flaring line until it intersects the center line of the figure at *f*; then *f* is the center from which the blank *A* is struck. The mold *B C D* would necessarily be divided into three sections to admit it being raised or stretched with the least amount of work; therefore a seam would be placed at *i* and *j*. This mold is averaged as explained in connection with Fig. 38, the average lines for the different portions of the molds *B* and *D* intersecting the center line of the figure at *h* and *k*, respectively, while the average line for *C* intersects the center line outside of the figure. Then using *h* and *k* as centers, the blanks or patterns for *B* and *D* may be struck, allowing, of course, the necessary laps for setting the work together. Assuming that the patterns have been joined at the ends, *B* would be raised on the lead block with a raising hammer, while *D* would be stretched on the blowhorn stake with a stretching hammer. The center section *C* would be slightly raised or drawn in at the top to meet *B*, while the bottom would be stretched or drawn outward to meet *D*, the joints being made as indicated in Fig. 39, by *1*, *2*, *3*, *4*, *5*, and *6*, parts *A*, *B*, *C*, and *D* corresponding to the parts similarly marked in Fig. 38. In Fig. 39 the flange at the top marked *1* is soldered against the bottom of the base of the cross, while the flange designated as *2* is joined to the narrow straight strip *b* made the required height. Part *B* of the mold has a flange at *3* which is soldered to *b*, and the portions of the mold *C* and *D* are joined at *4* and *5*. A flange is allowed at *6*, which is soldered to the upper portion of the crown mold. It will be noticed that all flanges are placed in such positions that water will flow over the seams, not against them, thus avoiding leaks. In (*a*) Fig. 40, is shown a lead block having circular hollows of the required size, on which the molds are raised by means of various sized hammers of the style shown at (*b*). At (*c*) in the same figure is shown a stretching hammer, by means of which a mold may be stretched on a blowhorn or mandrel stake. Sometimes in place of a lead block a piece of timber is used to raise the work upon. The top of the timber should be about 30 inches from the ground and should be 15 inches square or round.

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SOMETHING ABOUT LIGHTNING

Constructor

ITS PECULIARITIES—THE DAMAGE IT CAUSES—DO LIGHTNING RODS PROTECT?—SOME POINTS TO BE OBSERVED IN THE ERECTION OF RODS

NERVOUS people, and many of those not so sensitively organized, experience both physical and mental depression just previous to the occurrence of a thunder shower in their locality. This depression, whether it is caused by a natural antipathy, the varying electrical potential, or the unsettled atmospheric conditions, amounts in some cases to fear as the storm progresses. Popular remedies, originating no one knows where, were proposed as an antidote, or life preserver, for such timid people, and it was claimed that if these were followed they would insure immunity from lightning. Many of these popular theories have melted away in the strong light of scientific investigation, backed by carefully compiled statistics. Old ladies, or young, for that matter, can no longer feel secure from the dreaded lightning stroke when snugly ensconced in a feather bed; nor can glass an eighth of an inch in thickness be regarded as good insulation against a current that has cleaved its way through a thousand feet of air; and the statement that lightning never strikes twice in the same place cannot be considered as true in any degree, for the only thing that would prevent it from doing so is the fact that there is seldom much left of an object once struck.

The cause of lightning is generally said to be a discharge of electricity from the clouds to the earth, and its action, which has been compared with that of an avalanche, seems to be a sudden discharge of an accumulation of energy; it might be considered analogous to a cloudburst by regarding the difference in pressure as the force of gravity, the cloud as the reservoir, and the current, or lightning stroke, as the water. That lightning does considerable damage both to life and property is well known, and though the statistics on the subject have been difficult to gather, they are reasonably correct and give figures that are startling at least. In the United States, during four years beginning with 1890, 784 lives were lost, or an average of 196 per year, which is practically one person in every 400,000. This loss of life mostly occurs between April and September, but principally during the summer months. The property lost from fire caused by lightning, as gleaned from the insurance companies, fire departments, and newspapers, is hardly less surprising, for the total loss in this country during eight years previous to 1892 amounted to over $12,000,000.

Before the great liability to loss through fire caused by lightning and the efficiency of properly constructed lightning rods had been conclusively proven, Sir William Thomson, while addressing a meeting of the British Association for the Advancement of Science, said: "If I urge Glasgow manufacturers to put up lightning rods they say it is cheaper to insure than to do so." It would seem that the Glasgow manufacturers rather stood in their own light, since, in view of recently ascertained facts, there is no doubt that, when struck, buildings properly protected with lightning conductors suffer very little damage in comparison with those not so protected. That the placing of numerous lightning rods on any building will prevent it from being struck can hardly be conceded, but they certainly provide an easy path to the ground for the energy generated and tend to dissipate it in such a way that serious damage seldom results, where the lightning protection has been intelligently installed.

It has been a much mooted question as to whether the lightning rod should have a large sectional area or whether the section can be disregarded as long as ample surface is provided. For the direct current the section and material of the conductor are the factors that determine the resistance, but, after extensive experiments, the authorities agree that where the current is oscillatory, or alternating—that is, where it reverses many times a second—it travels on the surface of the conductor and never penetrates to the center. Lightning belonging to this latter class of electrical energy requires conductors having a large surface, and for this reason a strip of metal is considerably more efficient than a solid round bar of the same section.

The following amusing story related in

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the report of the Lightning-Rod Conference held in England some years ago will illustrate the differences of opinion of really great men on this subject until the high alternating currents of today settled the question conclusively: An old British admiral was called on to approve some specification for a lightning conductor to be used on a certain lighthouse. He was a believer in the "surface" theory of Harris, but thought he would consult his friend Faraday. Faraday, who saw only the question of conductivity in the problem, said very positively that the solid rod was better than the tube (which gives greater surface with less copper), and that solid volume was everything, superficial area nothing. Moreover, "if Harris says otherwise, then he knows nothing about it." The admiral straightway approved the solid-rod conductor for the lighthouse. Within two or three days he met Harris, and bringing up the question was told by Harris, "Surface area is most important, and if Faraday says otherwise, then he knows nothing whatever about it!"

All of the information regarding the construction and erection of rods for the protection of buildings from fire and serious damage likely to occur from a lightning stroke, together with a probable means of saving a person struck by lightning, has been gathered by Alexander McAdie and issued for the benefit of the public by the United States Weather Bureau, substantially as follows:

All barns and exposed buildings should have lightning rods. Ordinary dwelling houses in city blocks have not the need for rods that scattered houses in the country, and especially those on hillsides, have.

Use a good iron or copper conductor; if the latter, one weighing about 6 ounces to the foot, and preferably in the form of tape. If iron is used—and it seems to be in every way as efficient as copper—have it in rod or tape form, weighing about 35 ounces to the foot. "A sheet of copper constitutes a conductive path for the discharge from a lightning stroke much less impeded by self-induction than the same quantity of copper in a more condensed form, whether tubular or solid." (Sir William Thomson.)

The nature of the locality will determine to a degree the need of a rod. Places but a few miles apart will differ greatly in the relative frequency of flashes; in some localities the erection of a rod is imperative, while in others it is hardly necessary.

The very best ground you can get is, after all, for some flashes, but a very poor one; therefore, do not imagine that you can overdo the matter in the making of a good ground. An ordinary ground suffices for a great many flashes, but the small resistance of $\frac{1}{10}$ ohm for an intense oscillatory flash may be dangerous. Bury the earth plates in damp ground or running water.

"If the conductor at any part of the course goes near water or gas mains, it is best to connect it to them. Wherever one metal ramification approaches another, it is best to connect them metallically. The neighborhood of small-bore fusible gas pipes and indoor gas pipes in general should be avoided." (Lodge.)

The top of the rod should be plated or in some way protected from corrosion and rust.

Independent grounds are preferable to water and gas mains.

Clusters of points or groups of two or three along the ridge rod are recommended.

Chain or link conductors are of little use.

Very little faith is to be placed in the so-called "area of protection." The committee that first gave authority to this belief considered that the area protected by any one rod was one with a radius equal to twice the height of the conductor from the ground. Many lightning-rod manufacturers consider that the rod protects an area of radius equal to the height. The truth is that the buildings are struck sometimes within this very area, and it is now held that there is no such thing as a definite protected area.

There is no reason to doubt that the discharge takes place sometimes from earth to cloud; that is to say, while a lightning flash is considered as something like the discharge of a condenser through its own dielectric, made up of excessively frequent alternations, say something like 300,000 times per second, the spark, or core, of incandescent air may seem to have had its beginning at the earth's surface; in other words, the air gap breaks down first at a point near the earth.

Nearly all treatises upon lightning up to within very recent times assumed that lightning always followed the path of least resistance. "It is simply hopeless to pretend to be able," says Lodge, "to make the lightning conductor so much the easier path that all others are out of the question." The path will depend largely upon the character of the flash.

Any part of a building, if the flash be of a certain character, may be struck, whether

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there is a rod on the building or not. Fortunately, these are exceptional instances. The great majority of flashes in our latitudes are not so intense but that a good lightning rod well earthed makes the most natural path for the flash. We have many instances, however (not to be confounded with cases of defective rods), where edifices seemingly well protected have been struck below the rods.

Paradox of paradoxes, a building may be seriously damaged by lightning *without having been struck at all.* Take the famous Hotel de Ville of Brussels. This building was so well protected that scientific men pronounced it to be better protected against lightning than any building in the world. Yet it was damaged by fire caused by a small induced spark near escaping gas. During the thunder storm, a flash started "surgings" in a piece of metal not connected in any way with the protective train of metal. The building probably did not receive even a side flash. This is therefore a new source of danger from within, and but emphasizes the necessity of connecting metal with the rod system.

As lightning often falls indiscriminately upon tree, rock, or building, it will make but little difference sometimes whether trees are higher than adjoining buildings.

It is not judicious to stand under trees during thunder storms, nor in the doorway of barns, or close to cattle or near chimneys and fireplaces. On the other hand, there is not much sense in going to bed or trying to insulate one's self in feather beds; neither are small articles of steel so much to be feared, for they do not have the power to determine the path of discharge or to *attract* lightning, as is popularly supposed.

Many people suffer greatly and somewhat unnecessarily, we think, from *alarm* during the prevalence of thunder storms. Many flashes are of less intensity than we imagine, and the human body could withstand these without permanent serious effects. Voltaire's caustic witticism that "there are some great lords which it does not do to approach too closely, and lightning is one of these," needs a little revision in these days of high-potential oscillatory currents. Indeed, the other saying, "Heaven has more thunders to alarm than thunderbolts to punish," has much more point to it, as it is nearer the truth. *One who lives to see the lightning flash* need not concern himself much about the possibility of personal injury from that flash.

Finally, if you should be in the vicinity of a person who has just been struck by lightning, no matter whether or not the person appears to be dead, go to work at once to restore consciousness. There are many cases on record proving the wisdom of this course; and there is reason for believing that lightning often brings about suspended animation rather than somatic death. Try to stimulate the respiration and circulation. Do not cease in the effort to restore animation in less than an hour's time.

A GREAT COLLEGE YEAR

THIS will be the greatest college year that the United States or any other country has ever known. The Saturday Evening Post has taken some trouble to collect the returns from the different institutions of the country, and there is scarcely an exception to the report of an unprecedented increase in the number of students. This affects not only the universities, so called, but all the colleges of every class and size throughout the Union.

The collegiate institutions of the country, some four hundred in all, have a combined attendance of between one and two hundred thousand, and the total is not far from the two-hundred-thousand mark.

During and after all periods of prosperity the private schools and the colleges secure an increased membership, for the evident reason that people are better prepared to pay for the instruction of their children. That the figures have this year gone far beyond anything ever before known is, of course, largely accounted for by the increase in population; but, while allowing fully for all that, it is still true that the number has greatly exceeded any former proportion in the population statistics of the country.

The great thing is that the rush for higher education was never so strong or so general as it is in the present day.—The Saturday Evening Post.

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MYSTERIOUS EXPLOSIONS

How to Prevent Explosions in the Kitchen Range During Cold Weather—Simple Rules to be Observed

EARLY one morning when the wind was a piping gale and the mercury in the thermometer outdoors had dropped down below the zero mark, I sat leisurely enjoying my morning paper and in a kind of way sympathizing with the poor sailors on the sea and the ranchmen on the prairies. I reflectively scanned the headings that told as clearly as the text how the storm had been raging, how railroads were blocked, how the ocean liners were coming into their docks top heavy with ice, and lots of other things that are very interesting when you sit near a red-hot stove. But the heading that interested me so much that I read the text was one of those old-time headings that you find in all newspapers when the reporter does not know anything about his subject. The heading referred to was "Mysterious Explosion," and was set in big bold type. The text under it told about a stove or kitchen range being blown to pieces by the force of an explosion. The general public no doubt thought that a dynamite cartridge or some explosive material of a similar character got into the coal bin and that the cook accidentally shoveled it into the fire along with the coal. The reporter himself said that "the cause of the explosion is a mystery, but its force would seem to lend strength to the belief that it was due to a high explosive compound."

With all due respect for the reporter, I would say that it is a well-known fact that the explosion was caused by frozen pipes between the range and the boiler. Let me explain how such an explosion takes place. Inside the range and on one side of the fire is a hollow cast-iron box called a water back, or water front, as the case may be. This box is full of water all the time. Two pipes connect it to the boiler. The upper pipe leads hot water from the water back to the side of the boiler, and the lower pipe leads cold water from the bottom of the boiler to the water back. In fact, these pipes convey heat from the fire to the boiler by means of a current of hot water that flows through them. If they become frozen, the ice in them forms a solid plug and prevents the flow, so that if a fire is started in a range when these pipes are closed with ice, the water in the cast-iron box will become heated and its pressure will increase until it becomes too great for the casting to resist, when the water back will explode like a cannon and blow the stove to pieces.

For the benefit of the cook and all other people who attend to kitchen ranges during severely cold weather, we present the following suggestions:

1. Feel of the two pipes that connect the range to the boiler. Run your hand all over them the first thing in the morning, before you touch the fire. If they are warm all over, or even slightly tepid, they are safe. Then allow the water to run at any of the hot-water faucets for a few seconds. If this runs all right, the pipes in the house are safe also, and you may push along the kitchen fire.

2. Never touch the "sediment cock" at the bottom of the boiler. This is for the plumber's use only.

3. If the range pipes are quite cold, and water comes at any hot-water faucet, then thaw out the range pipes with burning paper and when warm start the fire, but do not start a fire upon any account until these pipes are warmed up, or you will run the risk of exploding the water back.

4. If the range pipes are warm but water will not come at the faucets, then send for a plumber at once and draw the fire until he comes.

5. If you come down to the kitchen any morning and find the fire out and signs of frost there, look out for yourself and go by the above rules.

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USEFUL IDEAS

REPAIRING A BROKEN STEAM PUMP

W. H. Wakeman

PEOPLE who live in localities where in the winter ice melts in the middle of the day and water freezes at night are thoroughly convinced that water expands when it freezes, because they are put to so much trouble and expense by the bursting of water pipes. When the thermometer rises to 50° Fahrenheit at noon and then gradually falls until it reaches 39°, water exposed to it will contract in volume. If the temperature continues to fall until the thermometer indicates 32°, the water will expand, but under ordinary circumstances this will do no harm because it still remains in the liquid form; but if the temperature continues to fall, the water is congealed into ice, and as it still expands,

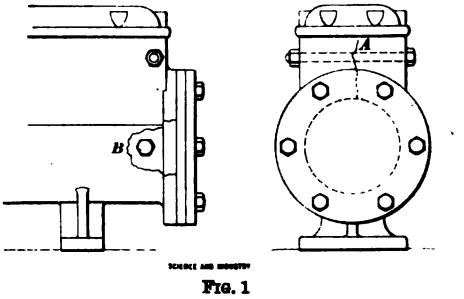

FIG. 1

something must stretch or break. Ordinary water pipe may stretch some, but it soon breaks.

The pump illustrated in Fig. 1 was left full of water by a careless engineer, and exposed to the weather. It was badly broken by the expanding ice. The clearance on the outer end of the water cylinder was very large, probably about three inches, which afforded an opportunity for a solid cake of ice to form there, and as cast iron cannot be claimed to be very elastic, the cylinder cracked from the top of the flange upward, as shown at *A*.

It was an easy matter to force white lead into this crack, drill a hole through each side of the water-valve casing, and draw the parts together with a suitable bolt, as plainly illustrated, but there was an irregular-shaped break at *B* that was not so easily repaired; still the large clearance made it a possibility. The job was offered to two different men and both declined to undertake it, as they claimed it was so badly broken that a new water cylinder was necessary. There were two objections to this plan, one of which was the expense, for the steam cylinder was 12 inches and the water cylinder 8 inches in diameter and had a stroke of 15 inches as near as I could estimate, for internal measurements were impracticable at that time; this is enough to show that a new water cylinder would have been expensive. The second objection was more serious, for the makers of the pump had gone out of business, and a new water cylinder could not be purchased at short notice.

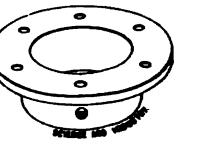

FIG. 2

An ingenious mechanic took the job in hand and finished it to the satisfaction of all concerned. A pattern was made in the shape of a straw hat, but it was round instead of oval, and had no crown in it, as shown in Fig. 2. A casting was made from this, and holes corresponding to those in the flange and cylinder head were bored in the rim. When this was made a sliding fit into the clearance of the water end it was put into place and a hole bored through the piece broken out by the frost and into the hat-shaped piece; it was then tapped out for a cap screw. The whole was then taken apart and the joints that must hold water under pressure were made up with white lead. They were allowed to stand until thoroughly dry, after which the pump was put into service and pumped water against 80 pounds pressure without a leak. The finished job, with the old cylinder head held in place by extra long cap screws, is shown in Fig. 1. I am not able to state the exact cost of these repairs, but it was not heavy when compared with the cost of a new pump.

REMOVING BOILER FLUES

Wilmot Kershaw, New Cumberland, W. Va.

WHILE I am not a boilermaker by trade, I have a great deal of this kind of work to do, and it may prove of interest to your readers to describe a method I adoped to take a flue from the middle of a boiler without taking

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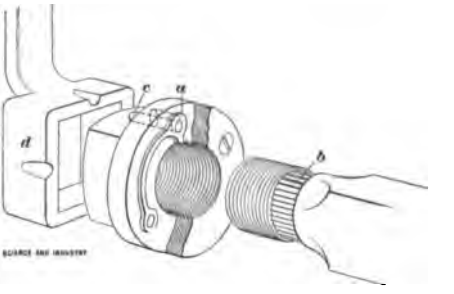
the whole row down. I tapered a wooden plug to about the same size as the flue, drilled a hole through the center, and at the small end cut a slot about half way to the large end. A rope was then passed through the plug and a knot tied in it at the small end of the plug. The rope was attached to a three-sheaved block and tackle, and the plug placed small end first two feet in the front end of the flue. A pull on the sheave block started the knot in the slot and thus spread and fastened the plug in the flue, which was then pulled without any trouble.

A NEW LOCK NUT

Carl E. Harling, Brooklyn, N. Y.

THERE are few if any mechanical devices upon which more thought has been spent than upon nut locks. I am aware that the nut-lock question is a long one and that there are a number of good ones on the market; but nearly all of them are in some form of washer, and none is really positive in action. They are used for railroad work, are not well adapted for fine work, and not at all suitable for axle work. For this last purpose I have contrived and patented the nut lock shown in the accompanying sketch.

The nut is made in two pieces and has a spring cog *a* inserted to engage a ratchet *b* stamped on the axle. A pin *c* extends from the cog *a* through the top of the nut, alongside the square part engaged by the wrench.



This pin works back and forth in a radial hole as the cog slides over the ratchet; but in case the nut is to be unscrewed, the special wrench *d*, with nicks for the pin filed in it as shown, will hold the cog away from the ratchet so that the nut may be turned. Otherwise, as is plain to be seen, the nut will never become loose or come off the axle.

EDITORIAL COMMENT

THE ROCHESTER RADIATOR

IT IS claimed that one-half the fuel now wasted through the chimney can be saved by the use of the radiator manufactured by the Rochester Radiator Co., which received the award at Paris. The apparatus costs from $2.00 up, and the money will be refunded if it is unsatisfactory. Write to the Rochester Radiator Co., Rochester, N. Y., for booklet describing their wares.

INDUCEMENTS TO BUILD AND RENT A SEWER SYSTEM

THE city of Marshall, Texas, with a population of about 10,000, has a fine system of water works but no sewers. The city is not in a financial condition to put these in, but offers favorable inducements to a company that would do so and rent the system to the city, the same as gas and water companies rent their business, charging annual rentals for sewer privileges. Parties interested in such matters can obtain full information by corresponding with Mr. Sid Coleman, Marshall, Texas.

TOOL POST GRINDING OUTFIT

THE Grant Manufacturing Company, 183 John Street, Bridgeport, Conn., have placed a grinding outfit for cylindrical grinding on the market. This outfit consists of a holder to be held in the tool post of the lathe, and an overhead drum; the holder carries a spindle on which the grinding wheel and the pulley for driving it is mounted. The drum is made entirely of sheet metal; this makes it light, true, well balanced, and safe at high speeds.

The outfit is well adapted for any tool room and machine shop where the quantity of cylindrical grinding will not warrant the purchase of a universal grinding machine.

THE ENCYCLOPÆDIA BRITANNICA

THE enterprise that enables the general public to possess so great a work as the Encyclopædia Britannica is worthy of praise. We feel that we can with propriety call the attention of our readers to the special offer in this issue of SCIENCE AND INDUSTRY that brings this excellent work within the reach

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of all our readers. A good encyclopædia is no longer considered a luxury but a necessity for every intelligent household. Among the published works of this kind the Encyclopædia Britannica has become the standard of all English-speaking countries of the world. It is scarcely necessary to refer in detail to the excellencies of this great work. It is known wherever the English language is spoken for its scholarship, thoroughness, and completeness. It has constantly improved since its first edition in 1771. Keeping pace with the intellectual growth of the centuries, the Britannica presents the gathered knowledge of the world. It is as good as a library of a thousand volumes. The many who have long wanted these magnificent books will now be able to secure them. The aim of the publishers seems to be to place a set in every home in the land, which is most desirable.

METAL POLISH

When the call for an article becomes so great that the manufacturer is compelled to enlarge his plant by the addition of new machinery to supply the demand, it is an indication that the article possesses great merit. Judged by this standard, it is not surprising that the metal polishes manufactured by Mr. George W. Hoffman, 295 East Washington Street, Indianapolis, Ind., are in such great demand by busy people who wish to make the most of the precious minutes in this time of great business revival. The polishes are put up in paste, liquid, and powdered form, and each variety has its particular use. The "U. S." metal polish paste is unequaled for polishing and cleaning gold, silver, plated ware, show cases, store fixtures, household utensils, and everything in the planished metal line. The ease of application and the rapidity of work have made these polishes a standard article with those who are acquainted with their merits. Write to the manufacturer for circulars describing these goods.

BOOK NOTICES

The Progress of Invention in the Nineteenth Century. By Edward W. Byrn, A. M. Octavo, 476 pp.; illustrations, 282. Cloth, $3.00. Munn & Co., New York.

We are constantly hearing of the wonderful progress of invention during the century just closing, and of the consequent advancement of art and industry. It is a subject dear to the heart of the postprandial speaker, the Fourth-of-July orator, and especially to him that finds pleasure in vaunting American supremacy in inventive ingenuity above all other nations of the earth. For such as these it would be impossible to imagine a more excellent *vade mecum*. It is a mine of suggestion of rose-colored rhetoric and impressive oratory. The announced purpose of its publishers is "to bring out a volume that worthily commemorates the completion of the nineteenth century; to record and describe all the important developments of the arts and sciences that distinguish the period; to give a most comprehensive, compact, and coherent account of the progress that distinguishes this as the Golden Age of Invention, resulting in industrial and commercial development without precedent."

If, however, one should happen to wish for exact and minute information on any particular discovery or invention, he must seek for it elsewhere; for this book will give him a knowledge available for nothing more than very general and sketchy conversation. It ranks very low in the class of literature known as popular science, and its purpose is clearly *ad captandum*. In the nature of things, therefore, it should command a ready sale and yield its author and publishers a generous return for a small investment.

The Gas Engine Hand-Book. A manual of useful information for the designer and engineer. By E. W. Roberts, M. E. Price, in flexible leather, $1.50. The Gas Engine Publishing Co., Cincinnati, Ohio.

This is a second edition of a work the worth and popularity of which are attested by the fact that the first edition was exhausted within a period of about 6½ months. The book has been enlarged by the addition of 20 pages of new matter, consisting of data for the design of two-cycle engines and notes of interest to all makers and users of gas and gasoline engines. The tables of dimensions of two-cycle engines, like the tables and formulas for the design of details that are presented in the main part of the book, will serve a useful purpose when supplemented by a good knowledge of the general principles of the gas engine and of machine design; it is, however, well to remember that gas-engine design is at present far from being a well established science and that empirical rules and formulas for the design of details must be based on a comparatively limited range of experience in a field in which the failures are rather more numerous and conspicuous than are the successes.

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ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

1. Put this address both on the envelope and at the head of the letter.

2. Only questions of general interest to our readers will be answered.

3. No questions will be answered by mail.

4. Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.

5. The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.

6. Reference to inquiries previously answered should give date of issue and number of question.

7. Questions cannot be answered in the issue of the month immediately following their receipt.

8. Any book not out of print and for sale by regular dealers may be ordered through the magazine.

9. We will not undertake to calculate windings of dynamos and motors, as this involves considerable work and is seldom justified.

MECHANICAL

(563) I am familiar with the formulas for computing the flow of water through pipes but do not know of any that I can apply to crude petroleum. How could a formula like "Kutter's" be so modified as to apply to crude petroleum and take account of the difference between its specific gravity and its viscosity at different temperatures as compared with water? F. W., Bakersfield, Cal.

ANS.—In the formulas for flow of water, the specific gravity of the liquid does not enter as a factor; if all other conditions were the same these formulas would apply to a liquid having a specific gravity greater or less than that of water. The effect of viscosity on the flow of a liquid cannot be calculated; it can be determined for any particular liquid only by experiment. The results of the experiments that have been made on water are expressed in the form of the empirical factors or *constants* that form a part of the various formulas. Before the formulas could be applied to a liquid having a different viscosity, it would be necessary to derive by experiment a set of constants similar to those that have been derived for water. So far as we have been able to learn, no reliable values for petroleum or any liquid but water have ever been published.

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(564) (*a*) What causes a circular saw, when running, to shake sideways at its circumference? (*b*) What can be the reason that the saw runs warm for about ¼ of the distance from the center outward toward its circumference? (*c*) Would hammering or stretching such a blade be advisable, and if so, where should the hammering be done?
J. O. W., Valla Hannis, Norway, Europe.

ANS.—(*a*) We have never seen an explanation of this phenomenon, and have no very satisfactory theory for it. If the saw is carefully centered and the plane of the circumference of the blade is perpendicular to the axis of rotation, it would seem as though the vibration must be caused by a lack of uniformity in the blade, possibly from the fact that the circumference of the blade is under too great a stress rom the "dishing" of the center. (*b*) We think the heat comes from the bearings of the saw arbor. (*c*) Hammering the circumference of the blade might stretch it enough to relieve the stress due to too much "dishing," or unevenness in the stress in different parts of the blade might be relieved by hammering. The best method of doing this work on a given saw could be determined only by personal inspection by an experienced man, and we would advise you to submit the case to such a man.

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(565) The water in the gauge glass of my boiler is continually on the move up and down—from a half to three-quarters of an inch. One person claims it is a sign of good circulation, while another claims the reverse to be the case. The boiler is of the return-tubular type, has been in use two months, and is free from scale. Can you explain this behavior of the water in the glass?
F. M. V., Omaha, Neb.

ANS.—We think that the movement you mention is due not wholly to circulating action, but rather, for the greater part, to some pulsating influence over and above this. If the boiler were supplying an engine of large cylinder capacity and a low rate of revolution, the intermittent drain on the steam supply in the boiler would, by momentarily relieving the pressure, cause the water to rise and fall. So, also, if the feeding were being done by a pump, the intermittent forcing in of a body of water (at each stroke) would cause the water level to rise and fall, although the amount would be quite small owing to the ratio of the injection per stroke to the horizontal section of the boiler at the water level; if the feed were injected at a point in the vicinity of the water column, the effect would be more noticeable. If neither of the above causes is present, the motion can only be due to a forcing of the boiler. In any case, you can view the present state of affairs with a certain amount of satisfaction rather than otherwise, because it is a sign that the openings into the boiler are clean—a point on which you would feel less sure if the water were always stationary, unless you made the test by opening and closing the cocks. In the case of a locomotive running along, the water is, of course, always on the move more or less; but that is to be expected, on account of the motion of the engine on her springs, due to roughness of track and other causes. But where a boiler is merely standing still under steam, we should not expect the motion of the water to be as great as you describe, even if the boiler were being worked hard.

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(566) Please give the names of cities in the United States where elevated trains are in operation, and what style or under whose patent are the gates used on the elevated cars. B R., Akron, Ohio.

ANS.—Elevated trains are in operation in New York and Chicago. Elevated roads are also being erected in Boston. In New York, a simple swinging iron gate is used and is operated by the conductor. The gate does not fold up, but swings back against the platform rail and is operated by means of a bell-crank lever. We do not know who controls the patents on these gates; your best plan would be to write to the roads using them.

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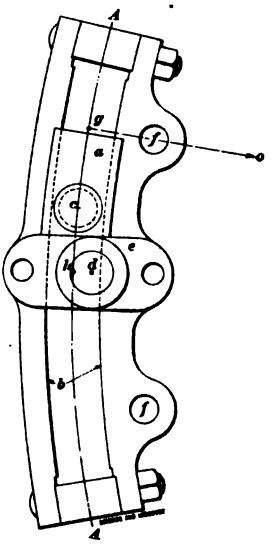
(567) Please state why the link block on a locomotive is not placed in the center of the link instead of being a little off the center. J. H. T., New York.

ANS.—Our correspondent evidently has in mind the saddle pin (or stud) and not the link-block pin, as a reference to our subjoined sketch will show. In this, *a* is the link-block, working freely inside the slot *b*. The link-block pin *c* connects the link block with the lower rocker-arm; this pin is always made central in the block and therefore works central with the slot *b*. (This same pin *c* continuing on through the rocker-arm, serves as the lower rocker-pin.) The block *a* takes up various intermediate positions between the two ends of the slot, according to the gear and the amount of expansion employed from time to time; but it is always central with the link transversely—that is, the center of pin *c* is always on the line *A A* (leaving the item of wear out of the question). The part that our correspondent refers to is the pin *d* which is centrally situated as regards the *length* of the link, but is placed off the center line *A A*, the amount of this offset being made to suit each different design of engine—$\frac{3}{4}$" or $\frac{1}{2}$", as a rule. The saddle *e* is made fast to the link, and the pin *d* is connected to the link hanger; thus, *d* is the point by which the link is supported. Now, it will be noticed that the eccentric-rod pins *f* are located behind the link arc *A A* (on the side next the eccentrics, in fact), and it is on this account that we have to set *d* off the center, the explanation being as follows: The effect of the pins *f* being behind the link arc *A A* instead of on it, is to make the cut-off occur earlier for the front port than for the back. For suppose there are two similar engines B and C, and that B has its eccentric-rod pins on the link arc, as at *g*, while C has her's at *f* as in the sketch; and suppose the length *o g*—i. e., from *g* to the eccentric center—to be 60 inches in each case. (For convenience of reference we have shown *o* in the sketch, although, as we have said, it is 60" distant from *g* in the direction of the arrow.) As the link vibrates to and fro, the center line of B's eccentric rod always maintains the position *o g*, while in C's case the line *o f g* is bent, the angle of bend being at *f*. Since the sum of the distances *o f* and *f g* remains 60", it is evident that the line joining *o* and *g* (which now falls outside the eccentric-rod's center line) is *less* than 60", and so the link lies nearer to the eccentric than in B's case. Thus the link is always drawn nearer to the axle, and if a rocker is used, the valve is pushed farther away from the axle. This means that the front port closes too soon, and the back port too late. This effect is partly corrected by the angularity of the main and eccentric rods, there still remaining a tendency to cut off early in front and late at back. Now, the nearer the block *a* is to either end of the link, the earlier will cut-off occur, and the nearer to the center *h*, the later. If, then, we can arrange matters so that at that part of the stroke where the cut-off occurs too early, the link shall drop down and bring the block nearer the end of link, and where cut-off occurs late, the link shall rise and bring the block nearer the center, we shall remedy the above defects. As the eccentrics revolve, the link vibrates to and fro around *d* as center, *d* itself describing an arc whose radius is the length of the link hanger. If we place the saddle pin *on* the link arc, at *h* instead of at *d*, the link as a whole will not rise and fall due to its vibration around the point of suspension; but it will do so if we set the pin away from the arc, at *d*. This is actually done in practice, as here shown. Then, when the piston is making the outward stroke and the valve is approaching the front end quicker than it should, the link will be falling (swinging round *d* like a clock hand, but in the opposite direction) and bringing the link block nearer into full gear and so retarding the cut-off. If the engine is running backward, the piston moving as before, the motion of the crankpin and eccentrics is reversed and the link rises, bringing the block nearer to the lower end of link, i. e., nearer to full *back* gear this time. On the return stroke in fore gear the limb will be rising, and in back gear falling, the result in each case being to bring the link block nearer the mid gear and thus hasten the cut off at the back end. Thus, the action of the link in alternately rising and falling is to approach nearer to or away from full gear, and so counteract the tendency to unequal cut-off due to offset pins *f, f*. If the lever is well over, cut off may occur in the latter part of the stroke, when the link is recovering from its highest or lowest positions, but is yet higher or lower than would be the case if *d* were not offset. The shorter the main and eccentric rods, the less the offset *h d* will be.



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(568) I have a horizontal return-tubular boiler under my care in which it is impossible to keep the tubes tight at the back end for more than a week or so at a time. The shell is 5 ft. 6 in. in diameter and 16 ft. long. There are 96 flues 3 in. in diameter. The boiler is clean inside; it is blown down 10 or 15 minutes twice a day, blow off being at the bottom of the back end. The tubes were renewed about 3 months ago; they remained tight about a month or 6 weeks and since then have been a constant trouble. I have rolled them out several times and when tested with cold-water pressure up to 100 pounds all would be tight; they would remain tight for a few days and then start to leak again. We burn rice coal with forced draft; it takes 10 to 15 minutes to clean the fires, the door being open all the time. I have given it as my opinion that the cause of the leaky tubes is the cold air admitted while cleaning the fires, my reason for this opinion being that they do not leak as much when under heavy firing. Please give me your opinion of the cause. J L., Ithaca, N. Y.

ANS.—There are several causes that might produce the leakage and the one you suggest is one of the most probable. It is possible that the feed enters the boiler in such a manner that the tubes or the back head are affected by the cold water: it may also be that the tubes are so close together that there is not enough metal in the plate surrounding them to hold them properly. The use of forced draft is sometimes thought to cause leaky tubes.

***

(569) Is there a vacuum above the piston in an indicator? If not, what determines the position of the piston and consequently the pencil, when scribing the atmospheric line on an indicator card? V N., Escanaba, Mich.

ANS.—There is no vacuum above the piston. When

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the pencil scribes the atmospheric line, there is atmospheric pressure on both sides of the piston. The upper end of the indicator spring is usually fastened to a head that screws firmly on to the cylinder cap. The lower end carries the piston. An adjustment is provided by means of which all lost motion is taken up, and any increase in pressure, beyond that of the atmosphere, on the lower side of the piston, will compress the spring and move the pencil.

***

(570) Please tell me the best way to turn, in an ordinary turning lathe, a sphere that will be as near perfect as can be judged by the eye.

H. A., Rockford, Ill.

ANS.—First turn the wood to a plane cylinder and then to the form shown in Fig. 1, the dimensions *a* being equal to the diameter *d*. Next, draw lines as shown in Fig. 2, so that the distance *b* shall be equal

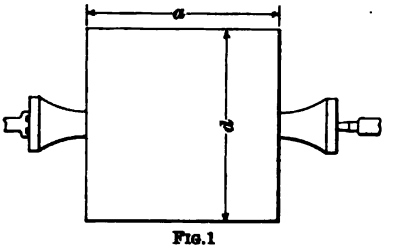

FIG. 1

to the distance *c* and also to the diameter of the circle *e*. The circle should be drawn on each end of the piece. These distances are determined by trial.

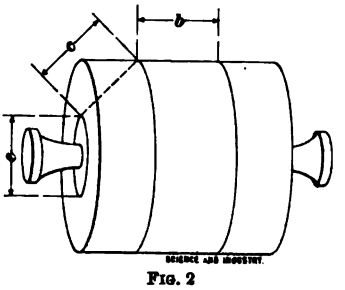

FIG. 2

The work is then turned to the form shown in Fig. 3, and lines drawn as shown. In this case, the distances *f*, *g*, *h*, and *i* are made equal, and the diameter of the circle *k* is made equal to distance *f*. The work is then turned to the form shown in Fig. 4, and after

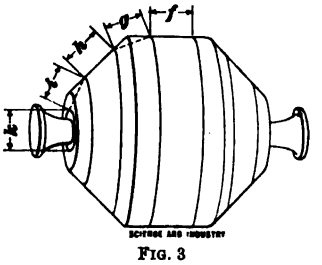

FIG. 3

this it is usually best to turn off the remaining angles, so as to obtain the ball as shown in Fig. 5. The ends are then carefully cut off, the ball placed in the chuck *a*, Fig. 6, and scraped round. The ball should be loosened from the chuck and given a partial rotation after it has been scraped for a few moments. By continuing this process it is possible to scrape a per-

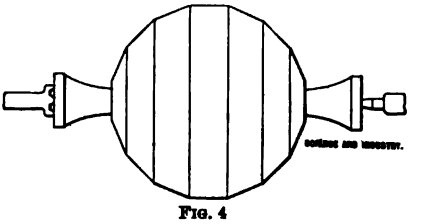

FIG. 4

fectly true round ball. Some operators prefer to place a piece of leather against the ball, and hold it by the

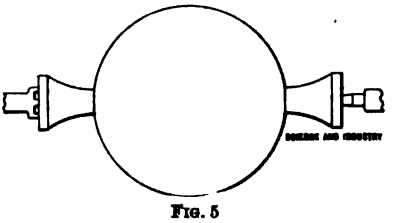

FIG. 5

lathe center as shown in the dotted outline, while others simply arrange the chuck so that the ball will enter to such a depth that it will be held and driven

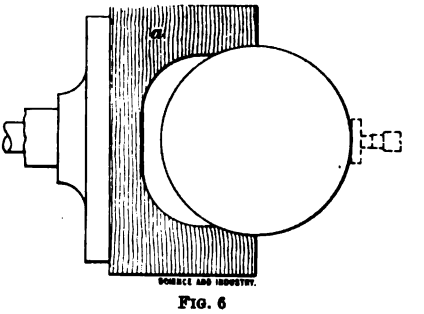

FIG. 6

by friction. The chuck is made by screwing a piece of wood to the lathe face plate, and boring it out so that it will just receive the ball as shown. Before removing the ball from the chuck, it may be finished with oil and shellac or any other suitable polishing material. The final turning is done by scraping with a skew chisel.

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(571) Please inform me whether I can run water into a boiler under a pressure of 70 pounds per square inch by the following method: Place a small pressure tank over the boiler; run a pipe from the bottom of this tank to the feed-pipe of the boiler; also have a pipe connecting the top of the tank with the steam space in the boiler, each of these pipes to be provided with a stop-valve. The tank will also have a pipe leading to it from the water supply, and this pipe will be fitted with a stop-valve. My plan is to close both connections with the boiler and fill the tank by opening the valve in the pipe from the water supply, then close this valve and open the valve in the steam pipe connected to the boiler until the pressure in the tank above the water is the same as the pressure in the boiler. The valve in the pipe from the bottom of the tank will then be opened so as to permit the water to flow to the boiler by gravity. We now use city water at a pressure of 70 pounds, and so have no pump. If the above plan

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is feasible, we can use a large amount of hot water that is now wasted. W. A. P., Pawtucket, R. I.

ANS.—The plan you propose is perfectly feasible. In order to get the water from the supply pipe into the tank it will be necessary to provide a vent for the escape of any air or steam it may contain; a cock or small valve at the top of the tank will serve this purpose.

***

(572) (*a*) Why is it that the plain triple valves are always used on switch engines? In switching a good many stops and starts are made within 20 or 30 minutes, and the braking power gets weak for the reason that the auxiliaries do not have time to charge properly and the reverse lever must be used frequently. It seems to me that if the quick-action valves were used, the train-line pressure would be obtained each time. Is this theory wrong? (*b*) What force produces the greatest stress—force that begins motion, or force that ceases motion? (*c*) Why is sliding friction greater than rolling friction? (*d*) If possible, give me a drawing of a dynamo that operates the electric headlight on a locomotive, and tell me what parts are subjected to diseases.

R. F., New Orleans, La.

ANS.—(*a*) Plain triple valves are used on switch engines in preference to quick-action triple valves for the reason that they serve the purpose intended as well if not better than the quick-action triple, and they cost considerably less. That quick-action triples would be more efficient than plain triples under the circumstances is a mistaken idea, due, probably, to an imperfect knowledge of the operation of the two valves in question. The statement that, in your opinion, *train-pipe* pressure would be obtained more quickly if quick-action triples were used, is not true, since the triple valves have absolutely nothing to do with the rate at which train-pipe pressure is increased. They do, however, regulate the rate at which their auxiliary reservoirs are charged. The quick-action triple valve contains two distinct sets of mechanism: one set is called the *service part* of the triple, and is used in making ordinary or service stops; the other, called the *quick-action* part, is only used in cases of actual emergency. The service part is practically the same as the ordinary plain triple, and its operation is actually the same. Hence, for service stops the plain triple is equally as good as the quick action for switch engines. Suppose the engine and tank were fitted with quick-action triples, and consider the result in case of an emergency application. The tank of a switch engine is almost always light in both coal and water; an emergency application with quick-action triples gives a brake cylinder pressure of about 60 lb. per sq. in.; the speed of the engine would be comparatively slow, and brakes hold much better at slow speed than at high speed; hence, the result of an emergency application would be to skid the wheels, and flat wheels would result. It thus will be seen that plain triples for switch engines are the better in emergencies. With ordinary triples there should be no trouble in recharging promptly while switching, provided the size of the feed groove in the triple is not reduced by gum and dirt, and the proper excess pressure is carried. To obtain the best results, the pump should be in good working order, the main reservoir should be of ample capacity, and, after releasing the brakes, the brake valve should be carried in running position, so that the proper excess pressure can be obtained. (*b*) If friction is neglected, the force necessary to start a body moving and bring it to a certain speed will just equal the force necessary to bring it to rest from that speed. If friction is considered, the force required to start the body will be the greater for the reason that the force of friction tends both to prevent the body moving, and, after it is in motion, to retard its motion and bring it to a state of rest. Friction, therefore, acts against the starting force, and with the force that stops the body. (*c*) Friction between two bodies is due to the roughness and unevenness of their surfaces. Two bodies may have polished surfaces and to the naked eye may appear perfectly smooth, yet under a powerful magnifying glass they will be seen to have minute elevations and depressions that fit into one another as shown in Fig. 1. When one of the bodies is made to slide over the other, these elevations are either ground off or flattened down. In either event a resistance to the movement is offered, the amount of which will depend upon the roughness of the surfaces. In the case of rolling friction, the elevations fit into the depressions, as shown in Fig. 2, and when one body is rolled along the other the action is somewhat similar to that of a toothed pinion rolling on a rack. The tearing and flattening action is very much less in this case than in the case of sliding friction, hence the frictional resistance is considerably less. (*d*) Space in these columns will not permit of our giving the drawings asked for. Illustrations of the different parts of the electric headlight apparatus, together with instructions for operating and for caring for the electric headlight, may be obtained by writing to the Pile Electric Headlight Co., Monadnock Block, Chicago, Ill.

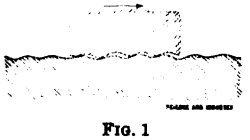

FIG. 1

FIG. 2

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(573) Please give me some information regarding the use of oil for fuel. I am thinking of using it in my 20 H. P. vertical boiler instead of the coke costing $5.50 a ton that I am using at present. The oil will cost 3 cents a gallon. How will the results in the two cases compare? R. K. G., Chicago, Ill.

ANS.—The advantages of using crude oil for fuel are: less storage space; less cost of attendance, there being no manual stoking and no ashes to handle and dispose of; smokeless firing; avoidance of the loss due to repeated opening of fire door (this objection to solid fuel vanishes when mechanical stoking is adopted); less cost of fuel, the saving in your case being about an eighth. The disadvantages are: objectionable odor; danger of keeping in bulk, some town authorities allowing this only under harsh restrictions; vapor given off is explosive, and necessitates the use of a more expensive form of oil; the necessity for either steam or compressed air for injecting and spraying the oil. It would thus appear that oil fuel is chiefly desirable where the plant is large and the labor involved is therefore greatest. In such cases, the use of oil has cut down the labor as much as 75%. In your case, the one man would still be required, whatever the fuel. There are other and special reasons for using oil at sea; also, in countries where coal is scarce and oil is plentiful, the use of the latter for both stationary and locomotive purposes is desirable. If you decide to use oil, and can get steam or compressed air elsewhere, cover your grate with firebrick and keep the ash-pit door closed. If unable to get steam or air, leave the grate as it is and use oil as an auxiliary to the coke. The oil is fed to the firebox by an injector similar in principle to the boiler injector. We subjoin an outline of the method adopted on the G. E. Railway.

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England: Oil enters the injector through a pipe from the tender; steam from the boiler enters the injector and forms an annular jet that sprays the steam and also induces a current of air through a central air tube connecting with a hot-air pipe leading from a coil in the smokebox. Just behind the nozzle is a ring containing small holes through which steam flows and impinges on the escaping jet of oil, thus helping to further break up and spray it. This escaping steam also draws a current of air into the box, which aids the combustion. Thus there are two bodies of steam and two of air entering the box along with the oil. Two injectors are used, the nozzles projecting about half way through the water space. The nozzles form a Y branch at the end, the result being to send the two outer streams straight across the box, the two inner ones crossing each other at the center of the box. A short vertical length of brick runs down from below the junction of the arch and tube plate, forming a wall toward which the streams are directed. A thin bed of incandescent solid fuel is kept on the grate, its rapid consumption being retarded by allowing but very little draft through the dampers. These engines do the same work on 2 pounds of oil as on 3 pounds of coal. Your boiler being already made, you could inject the oil through the fire hole, the door being closed except for that.

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(574) Please give me some information as to the best method of laying off key seats on shafts for compound and triple-expansion engines and also on the same shaft at different angles. Is there any tool or instrument manufactured for this purpose? If so, who makes it? N. A. K., Rankin, Pa.

ANS.—There are quite a number of ways of laying off the key seats on engine shafts; to describe them even briefly would take more space than we can spare in these columns. As you know, there are a great variety of designs of engine shafts, and as not all shops have the same facilities, the job of laying out the keyways is one that is governed by the conditions of each particular case and the facilities available. We published an article on the laying off of eccentric keyways in the November, 1898, issue of "Home Study for Machinists, Etc." from which you can probably obtain some ideas. You can obtain a copy of it from The Colliery Engineer Company, Scranton, Pa.; price, 5 cents. We do not know of any tool or instrument for this purpose except the so-called key-seat rule that is made by the Brown & Sharpe Manufacturing Company, Providence, Rhode Island, and L. S. Starrett & Company, Athol, Massachusetts.

ELECTRICAL

(575) What substance or combination of substances offers the greatest resistance to the passage of lines of force? C. D. C., Pacific, Mo.

ANS.—Diamagnetic substances offer a slightly higher resistance to the flow of magnetism than air or other non-magnetic materials. For all practical purposes, however, an air space and all non-magnetic substances offer as high a resistance to magnetism as anything that can be obtained. Bismuth is the most diamagnetic substance, but the difference between its resistance and that of other non-magnetic materials is insignificant.

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(576) We have a telegraph line 263 miles long, having a resistance of 10 ohms per mile and containing seven 150-ohm relays in the circuit. According to the answer to question No. 411, in the September number, our lines should require 120 gravity cells, whereas we only use 60, and in fine weather only 45, and our line works well and rapidly. Please explain the discrepancy. W. A. D. P., Orizaba, Mexico.

ANS.—If you use polarized relays the discrepancy is easily explained, because they require much less current than an ordinary neutal relay of the same resistance. If you use the ordinary 150-ohm neutral relay, such as we use in this country, we can offer no explanation, except that you are probably mistaken concerning some of your data. The very best telegraph engineers in this country allow at least 30, and more often 40 to 50, milliamperes for a circuit containing ordinary 150-ohm neutral relays. The solution and formula given in answer to question No. 411 is certainly correct.

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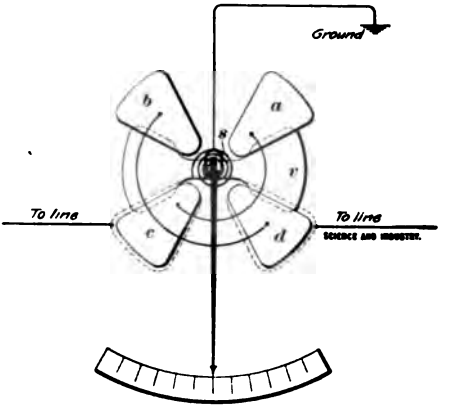
(577) Please explain the construction of an electrostatic ground detector. What material is used for the vanes? What is their shape and thickness, and what is the proper distance between the fixed vanes and the movable vanes?

F. M. VAN D., Purcell, I. T.

ANS.—The appended sketch illustrates an electrostatic ground detector. There are 6 fixed vanes, *a*, *b*, *c*, and *d*, and two vanes set into the base of the



instrument, under vanes *c* and *d*. The four vanes *a*, *b*, *c*, and *d* are connected together in pairs, as shown, but are carefully insulated from connection with any active part of the instrument. One of the plates insulated on the base of the instrument is connected to one line wire and the other base plate to the other line wire. Between these two sets of fixed vanes is a movable vane *v*, mounted on a jeweled bearing and held in the central position by a spring *s* when the instrument is in its normal position. A pointer is attached to the movable vane. This vane is carefully insulated from any connection with the fixed vanes, but is connected to the ground as shown. The fixed vanes, which may be made of brass or aluminum, are each about 4 inches long by 2½ inches maximum width and about $\frac{1}{16}$ inch in thickness. The two primary fixed vanes are insulated by being embedded in the base. The movable vane, which may be made of aluminum, is about 8 inches long by 3 inches maximum width and $\frac{1}{32}$ inch in thickness. The sides of the fixed vanes facing the movable vane may be covered with hard rubber, so that it will be impossible for the movable vane to make contact with any of the 6 fixed vanes. Allow a space of ¼ inch between the movable and the fixed vanes.

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(578) What size of resistance wire should be used in making a rheostat to be used on a 100-volt alternating-current line? It is the Westinghouse transformer system. R. O. S., Kingwood, W. Va.

ANS.—You do not furnish sufficient data for the purpose. It is necessary to know the nature of the work to be performed by the rheostat; the amount of current; the E. M. F. of the line and the desired drop in potential between the terminals of the rheostat when all the resistance is in circuit; the number of resistance steps, if the apparatus is to be used to regulate the speed of a motor or the amount of current flowing through a piece of the apparatus; and all the other necessary information for a careful design.

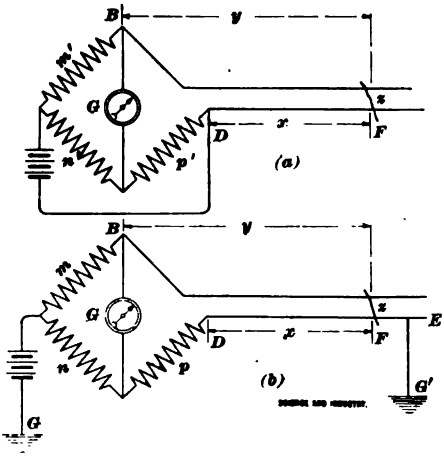
***

(579) Please explain how a cross between two line wires may be located with and without an available good wire. J. W., Richmond Hill, L. I.

ANS.—Probably the best way is by the use of the Varley loop method, which is as follows: First open or insulate the distant ends of the two crossed wires and connect the near ends to a Wheatstone bridge as usual when measuring an unknown resistance and as shown at (*a*). Balance the Wheatstone bridge in the usual manner and let the resistances unplugged in the three arms be m', n', and p', respectively. Then R, the unknown resistance, is found solving the usual Wheatstone bridge proportion, that is, $R = \frac{m'p'}{n'}$. Let z be the resistance at the cross F, such as a third wire lying across the two and causing the cross. It also includes all contact resistances. Let y be the resistance from B along one wire to the cross F, and let x be the resistance from D along the other wire to the cross F. Then, evidently, the resistance measured above is

$$R = x + z + y. \qquad (1)$$

Now ground either wire, say DE, anywhere beyond the cross. This would usually be accomplished by



requesting the distant station, at the beginning of the test, that is, before the preceding measurement of R was made, to ground DE at the end of a certain time. If it is absolutely impossible to communicate with the distant station and there is no ground on either wire beyond the cross, then the rest of the test cannot be carried out, and about the nearest you can come to locating the cross is to take $\frac{1}{4}R$ as the resistance from D or B to the cross. Half the resistance at the cross will be included in this result, and hence it will be incorrect by that amount, which is, of course, an unknown quantity. Assuming, however, that DE is grounded beyond the cross, then connect as in (*b*), that is, connect one terminal of the battery to the ground G instead of to D as in (*a*). Again balance the Wheatstone bridge. If m, n, and p are now the unplugged resistances in the three arms of the bridge, then

$$\frac{m}{n} = \frac{y+z}{p+x}. \qquad (2)$$

By solving equations (1) and (2) for x we get $x = \frac{nR - mp}{m+n}$. Then, by dividing x by the resistance of a unit length of the wire DE, the distance from D to the cross along the wire DE is obtained. If the size of the wire DE is known or measured, this resistance per unit length may be obtained readily from a wire table. In case a third good wire is available, it may be used in place of the ground, in the last figure. That is, instead of connecting the battery to ground at G and the wire DE to ground at G', connect them both to this third good wire. This will evidently not alter the test or the result in any manner, for this wire merely replaces the ground circuit.

***

(580) (*a*) Why is it that an ordinary magneto will not operate an induction coil? (*b*) I have about 4,000 feet of No. 30 wire that I would like to use for the secondary of an induction coil. Please give directions for making a coil, or give the name of some book on the subject. J. E. M., Cincinnati, Ohio.

ANS.—(*a*) The magneto-generator armature furnishes a low-frequency alternating current. If the interrupter on the induction coil is screwed down so that it cannot open the circuit, and the alternating current from the magneto sent through the primary coil, the effect at the terminals of the secondary coil will probably be slight. The primary coil has a small number of turns of wire wound on it, and the current from the magneto is also very small. This results in a small number of primary ampere turns, and there is therefore a weak magnetic effect in the iron core. The polarity of the coil is changing, due to the alternating current in the primary coil, but as the magnet flux through the core is weak, only a small E. M. F. is set up in the secondary coil. When current from a battery is sent through the primary coil, and the circuit suddenly opened by the interrupter, the current in the primary, which has a fairly large value, is quickly stopped, and the magnetic lines set up in the core by this current suddenly change from a large to a very small number of lines. This rapid change in the number of magnetic lines in the core induces a high E. M. F. in the fine-wire secondary. (*b*) "Induction Coils," by Bonney; price $1.00. This book may be purchased from The Technical Supply Co., Scranton, Pa.

***

(581) (*a*) How must dynamos be wound in order to be used for charging storage batteries? (*b*) Where can such a dynamo be obtained? (*c*) How many cells of storage battery would be required to work a ½-inch spark induction coil? (*d*) Would the shock from such a coil be dangerous? (*e*) What would be the voltage of the coil? J. K. F., Chewsville, Md.

ANS.—(*a*) As shunt or compound-wound direct-current dynamos. (*b*) From any of the well-known makers of dynamos, such as the General Electric Co., Schenectady, N. Y., or the Crocker-Wheeler Co., 39 Cortlandt St., New York City. (*c*) Three cells would be sufficient. (*d*) Yes. (*e*) It would depend largely upon the quickness of the break at the point of the primary coil interrupter and upon the shape of sparking terminals. When the coil is delivering

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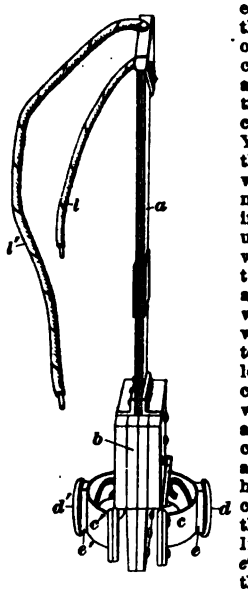
½-inch sparks, with needle-pointed sparking terminals, the E. M. F. across the terminals of the secondary coil will probably be from 10,000 to 12,000 volts.

***

(582) Please give an illustration and description of the most approved underground contact device in use on the underground trolley system.

T. C. H., Baltimore, Md.

ANS.—The device used to convey the current from one of the conductor rails in the conduit to the electrical apparatus on the car and back to the other conductor rail, is called the car plow. The accompanying illustration shows the style of car plow used in New York City. *a* represents the shank of the plow, which is $\frac{1}{16}$ inch in thickness, including the wearing plates. It is made up of two steel plates with spacing plates between them, so arranged as to provide grooves in which are placed flexible wires, connected at the top of the plow to the car leads *l*, *l'*. These wires come out through *b*, the wooden base of the plow, and are connected to the cast-iron plow shoes *d* and *d'*. The shoes are held in contact with the conductor rails by the thin steel springs *c* and *c'*. Insulating blocks *e* and *e'* are placed between the shoes and the shoe springs. The car plow is mounted under the car body in such a manner as to be easily moved from one side of the car to the other. The slot rails may therefore be to one side of the center, between the rails. The plow extends downward between the slot rails, to make contact with the conductor rails on each side of the conduit.



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(583) (*a*) I was recently informed that a dynamo to be installed here to light the ore dock is to furnish current for both arc and incandescent lamps. What kind of apparatus and what kind of a dynamo would be used for such a system? If an armature were provided with two windings and two commutators, one for constant current and the other for constant potential, both utilizing the same field, would it be possible to regulate the potential to the required figure in both circuits? If so, by what means? (*b*) Has the Tesla oscillator and lighting by phosphorescence been put to any practical use?

V. N., Escanaba, Mich.

ANS.—(*a*) The dynamo referred to is doubtless a constant-potential direct-current machine, or else a constant-potential alternator. If constant-potential direct-current is used, enclosed arc lamps will likely be operated in parallel in the same way as the incandescent lamps. If alternating current is used, enclosed constant-potential alternating lamps fed from ordinary transformers may be employed. Alternating constant-current lamps may also be operated from a constant-potential alternator by using a special transformer that will transform from constant potential to constant current. A number of systems are now on the market by means of which an ordinary constant-potential alternator can operate arc lamps in series and at the same time operate incandescent lamps in the ordinary way. In the case you mention, it is very likely that direct current at constant potential will be used if the distances are not long, in which case the lamps will be operated in parallel either singly or in groups of two in series. It would hardly be practicable to make a machine of the kind you mention, having a field common to both armatures. In the constant-current machine, the changes in field strength caused by the heavy armature reaction and necessary for constant current regulation, would make it practically impossible to keep the pressure uniform on the constant-potential side. (*b*) No; lighting by this means has not progressed beyond the experimental stage.

***

(584) Please explain the following statements that seem to be contradictory. The velocity of sound waves through a medium is given by the formula, $v = \sqrt{\frac{E}{d}}$, in which v represents the velocity, E the elasticity, and d the density, all expressed in absolute units. In Daniel's Principles of Physics I find the statement: "Gases * * * have elasticity of volume only and in this they are perfect." It is a well-known fact that sound is transmitted more rapidly through steel, for instance, than through a gas such as air. The steel is, of course, much more dense than the air and its elasticity is not perfect. Is it true that gases have volume elasticity only and is it by virtue of volume elasticity that sound is transmitted?

C. H. A.

ANS.—In the formula you have quoted, E is the modulus of elasticity of any medium in which the sound wave travels; E may be defined as the rate of change, in a unit of a body, of the stress with respect to the strain. Hence the modulus of elasticity of a gas, that is, its volume elasticity, is measured by the limit of the ratio (that is the rate of change) of any small change of pressure (stress) to the corresponding change of unit volume (strain). Thus, if a perfect gas has a pressure of 2 and a volume of 6 and the pressure be doubled, the volume will be reduced to ½ of 6, or 3; that is, each unit volume is reduced to ⅓ a unit volume. The increase in the pressure is $4 - 2 = 2$. Hence, the ratio is $\frac{2}{\frac{1}{2}} = 4$. But 4 is now the pressure of the gas. Therefore, $E = p$ for a gas, as you will find stated in your Daniel's Physics. While the elasticity of a solid is not perfect, by any means, still the modulus of elasticity is so much greater than it is for a gas that it requires an enormouly greater force to compress a cubic inch of steel a certain amount than to compress a cubic inch of any gas the same amount. Although the density of steel is much greater than the density of a gas, still the modulus of elasticity of steel is so very much greater than the pressure of a gas that the velocity of sound through steel is greater than through air. It is true that gases have volume elasticity alone. If a gas possessed absolutely no elasticity it would not transmit sound, and hence it is due at least partially if not wholly to its elasticity that sound is transmitted through it.

***

(585) Please give me a process by which I can recoat carbon brushes, such as are used on motors. Kindly give the cheapest method you know of.

A. B., Salt Lake City, Utah.

ANS.—The carbons may be coated by electroplating them. Make a solution as follows: sulphate of copper (bluestone), 1 lb.; sulphuric acid, 1 lb.; water, 1 gallon. The sulphate of copper is dissolved in hot water, after which cold water is added until the quantity named is made up. The sulphuric acid is then added, and after the solution has become cool, it is poured into the depositing vessel. The vessel in which the plating is carried on may be either of glass

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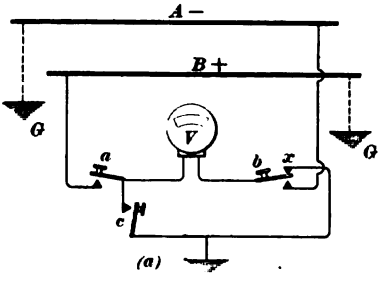
or wood, but in either case it should be thoroughly cleaned before using. Hang a copper plate in the solution and connect it to the positive pole of a dynamo or a number of cells of gravity battery, so that the current will flow from the plate, through the solution, to the brushes. Suspend the brushes by means of copper wire, so that they may be connected to the negative pole of the dynamo or battery. A resistance should be included in the circuit, in order to regulate the current. If the current is too strong the deposit will be rough and granular in character, and will not likely adhere well.

***

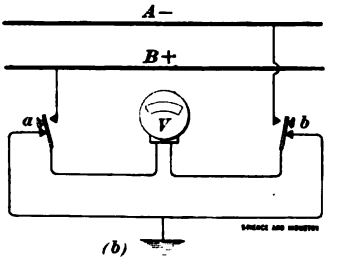
(586) (*a*) What is meant by "aging of a transformer"? (*b*) What is meant by "motoring"? (*c*) Please give directions for making a spark coil for gas lighting to operate two burners. (*d*) Does electricity have any physical effect on wire? I have noticed that old wire removed from buildings is more brittle than new. (*e*) Please give in brief the theory of metallic and electrolytic conduction. (*f*) Not long ago I was helping on a switchboard which was to have a voltmeter switch arranged with three push buttons, one for bus-bar voltage, one for positive ground, and one for negative ground. It was found that this combination would short-circuit the bus-bars. What I would like to know is whether it could be done with these three buttons.

C. B. S., Baltimore, Md.

ANS.—(*a*) In the cores of all transformers there is a loss in energy known as the *hysteresis* loss, which is caused by the resistance that the iron offers to having its magnetism changed. It is generally attributed to a kind of molecular friction in the iron. It is found that this loss in transformers increases after



(*a*)



(*b*)

the transformer has been in use for some length of time, and this increase in hysteresis loss is known as "aging." The increase may be quite large if care is not exercised in selecting the quality of the iron used in the transformer core. (*b*) "Motoring" is a term sometimes used to designate that a machine which, under normal conditions, runs as a dynamo, is made to run as a motor by current from some other machine flowing back through it. For example, when two dynamos are running in parallel and the voltage of one of them drops so low that current from the other flows back through it and runs it as a motor, the machine is spoken of as being "motored." (*c*) Make up a core 8" long and ¾" in diameter, of straight annealed iron wire (about No. 18). Provide this with two wooden heads about ¾" thick, and after insulating the core wind on it about 4 layers of No. 18 B. & S. double cotton-covered wire. (*d*) The flow of current through copper wire makes it slightly more brittle, but the old wire you noticed may have been drawn harder in the first place than the new wire. (*e*) Space does not permit us to give an outline of the theory of conduction in electrolytes and metals that would be at all satisfactory. We would advise you to read this matter up in S. P. Thompson's "Elementary Lessons in Electricity and Magnetism" or Oliver Lodge's "Modern Views of Electricity." Both of these books may be procured from The Technical Supply Co., Scranton, Pa. (*f*) This may be accomplished by slightly modifying one of the push buttons. The accompanying sketch (*a*) shows the arrangement, button *b* being provided with an extra contact *x* which remains closed as shown when the button is not in use. To get the bus-bar voltage, press *a* and *b*. To test for a ground *G* on the + side *B*, press *b* and *c*. To test for a ground on the − side *A*, press *a* alone. Sketch (*b*) shows a neater arrangement, using two double-contact push buttons. In this case, both buttons are pressed to get the bus-bar voltage. For a ground on *B*, press *b*. For a ground on *A*, press *a*. Of course, the double-contact push buttons must be arranged so that the back contact is broken before the front contact is made.

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(587) (*a*) Could copper be plated with copper to a thickness of $\frac{1}{16}$ inch with the apparatus you describe in the July number under the head of "Galvanometer" (page 318)? (*b*) Can you recommend a treatise on the subject?

J. H. P., Cleveland, O.

ANS.—(*a*) Yes, it could be done, but the apparatus there described is not well adapted for practical electroplating work. It would be somewhat difficult to get a perfectly even coating $\frac{1}{16}$ inch thick, but you should have no difficulty in doing it with a regular plating outfit. You can obtain full particulars relating to such an outfit by writing to Gray & Co., Miami Building, Cincinnati, O. (*b*) "Electroplaters' Handbook," by G. E. Bonney, may be obtained from The Technical Supply Co., Scranton, Pa. Price, $1.20.

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(588) The cars on the 42nd St. and Grand St. crosstown lines are run by an electric battery. Every second or third trip they run the car into the house and replace the battery. I wish to make a battery large enough to drive a small motor from ½ to 1 H. P. and to operate from 10 to 12 16 c. p. lamps. Will you please give me full particulars for making it, what carbons, zinc, acid, wire, etc. to use?

L. H., New York City.

ANS.—The batteries you refer to are storage batteries and are made out of lead. Zinc and carbon are not used in their construction. These batteries are charged up from a dynamo and they are the only kind that would be practicable for the amount of power you need. It would be very expensive and troublesome to supply about 2 H. P. as you wish to from primary batteries using carbon and zinc. You will find instructions for making a storage battery in the June, 1900, number of SCIENCE AND INDUSTRY. The number of cells required would depend upon how long you wished to operate the lamps and motors without recharging the battery. To operate the 10 lamps and at the same time supply ½ horsepower to

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the motor for a period of 1 hour, would require about 30 cells of the kind described in the article referred to.

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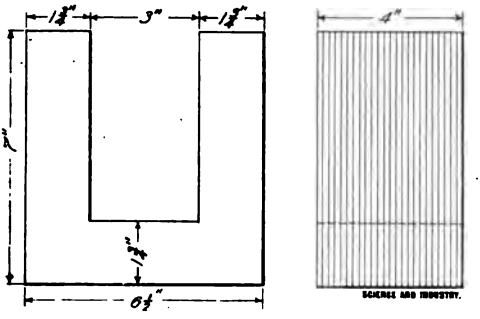
(589) The accompanying sketch shows a laminated iron magnet. What is the proper size and amount of wire to wind this for alternating current, 104 volts, 16,000 alternations? I wish to get the greatest magnetizing power possible with a reasonable amount of current. Give method of figuring also. F. M. V., Purcell, I. T.

ANS.—With a frequency as high as 16,000 alternations per minute it will not be advisable to work with a magnetic density in the iron much higher than 25,000 lines per square inch, otherwise the loss in the car will become excessive and cause heating. The frequency is 16,000 alternations per minute, or $\frac{16,000}{2\times 60} = 133$ cycles per second. The voltage to be applied is 104. The part of the applied voltage necessary to overcome the ohmic resistance will be



very small compared with that required to overcome the counter E. M. F. in the coil, and it will be sufficiently correct to assume, in this case, that the winding generates 104 volts counter E. M. F. We have the formula giving the relation between the E. M. F., E, frequency n, total flux N, and turns T as follows: $E = \frac{4.44\,N\,T\,n}{10^8}$; hence, $T = \frac{E\times 100,000,000}{4.44\,N\,n}$. Assuming that the laminated iron core is 90% iron, the cross-section of the magnetic circuit threading the coils is $1\frac{1}{2}'' \times 4'' \times .9 = 6.3$ sq. in., and since the magnetic density is to be 25,000, the total magnetic flux is $25,000 \times 6.3$. We have, by substituting in the above formula, $T = \frac{104\times 100,000,000}{4.44\times 25,000\times 6.3\times 133} = 112$, nearly. The magnet would, therefore, be wound with two coils of 56 turns each, connected in series. The size of wire will depend on the current, and this, in turn, depends on the reluctance of the magnetic circuit and the hysteresis loss in the core. The reluctance will vary greatly, depending upon whether or not there is an armature on the magnet. It will be advisable, therefore, to use a wire of liberal cross-section, say No. 10 B. & S.

***

(590) What rules are in use, in cities of 70,000 inhabitants, in the United States, to obviate the induction between telephone and other line wires that run parallel and near together? The telephone company here use a ground return. The telephone wires and our lines are never closer than 4 feet. The telephone company claims that we should move our wires away from theirs to avoid induction and we claim that the most natural remedy is for them to use a metallic return.
E. D., Monterey, Mexico.

ANS.—To our knowledge there are no rules for avoiding induction by regulating the distance between telephone and other line wires in any city in this country. It has been decided and is well recognized that the remedy is in the hands of the telephone companies. When they are seriously troubled by induction, their only remedy is the use of a complete metallic circuit, two line wires for each telephone circuit, and the transposing of each pair of wires as often as necessary. They cannot compel any other company to move or alter the disposition of their line wires merely in order to reduce or to avoid the disturbing current that the latter lines may induce in the telephone lines.

***

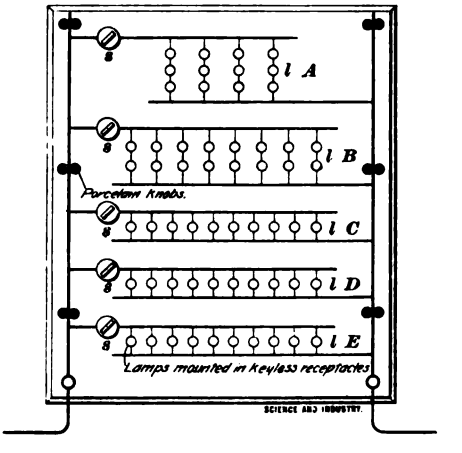
(591) What is commonly meant in telegraph parlance by a "double-wound relay"?
W. M. L., Mt. Savage, Md.

ANS.—Differential-wound relays are frequently called "double-wound relays." The latter, however, is not a good term, because a multiple-wound relay might equally as well be spoken of as a double-wound relay. A differential-wound relay is one containing two windings so connected that the current divides and an equal amount flows in each winding in opposite directions, producing as a consequence no magnetism in the cores of the relay. However, if the current passes through either coil alone the relay is magnetised. A multiple-wound relay is very similar, but the coils are so connected that the current in each coil helps that in the other. Many railroad companies have been changing their ordinary 150-ohm relays to 37.5 ohms by connecting the two coils in parallel instead of in series.

***

(592) How can I wire lamps to secure any resistance from them? G. M. D., Yonkers, N. Y.

ANS.—The accompanying sketch shows a form of lamp board that might be used to give a considerable range of resistance. The actual range obtained would depend upon the number and size of lamps. In this case we have shown 58 for the sake of illustration; l, l are the lamps divided into five groups



A, B, C, D, E, each group controlled by a switch s. We have here shown snap switches, but small knife switches would be more durable. The individual lamps may be cut out by screwing them out slightly in their sockets. The highest resistance obtainable is that of 3 lamps in series, and the lowest that of all the lamps or series of lamps in multiple.

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BUILDING TRADES

(593) (*a*) Is it possible to construct a projecting gallery or platform as shown in Fig. 1? (*b*) How may the discrepancy between the areas of the several figures shown in Fig. 2 be explained, when they all have the same perimeter? (*c*) Give a formula by which the force or wind pressure required to push over a wall may be obtained, and explain by an example. Also what force will be required if applied only at the top, as designated in Fig. 3.
J. M., Jr., Belleville, Ill.

ANS.—(*a*) Hardly; the leverage would be too great, and the chances are that the I beam spanning the

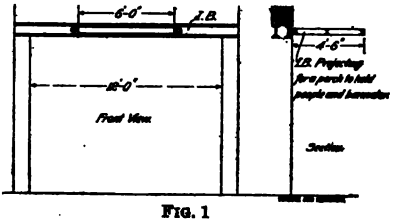

FIG. 1

opening would be twisted out of place or that the strain upon the connection would be more than it could possibly stand. A far better way would be to so arrange the gallery or platform that its supporting beams would extend through the wall above the beams spanning the wall opening and be secured to the floor system, well inside of the building. (*b*) There is no relation existing between the perimeters and the areas of dissimilar figures. The circle is the only geometrical figure that attains the maximum area enclosed within a minimum length of perimeter. The less any geometrical figure resembles a circle in which every point in the perimeter is equally distant from the center, the greater is its perimeter in comparison with its area. (*c*) The formula by which the wind pressure necessary to overturn an unsupported wall may be stated, is $P = \frac{Wl}{l'}$. In this formula, P = the entire wind pressure required to overturn the wall (the pressure per square foot is obtained by dividing P by the exposed area of the wall in square feet); W = the weight of the wall in pounds; l' = the distance in feet from a vertical line passing through the center of gravity of the wall to a point one-sixth of the width in from the edge of the wall at the bearing surface; and l = the distance in feet from the base of the wall to the center of the action of the wind pressure.

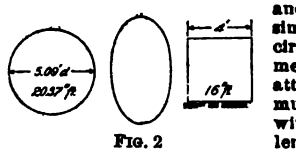

FIG. 2

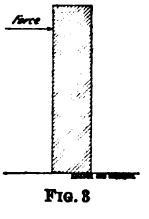

FIG. 3

For example, assume that a brick wall 15 feet high, 20 feet long, and 2 feet thick has no support but the stability created by its own weight. The weight of the wall, if laid in cement mortar, is about 130 pounds per cubic foot, and figuring on this basis, its entire weight is equal to $15 \times 20 \times 2 \times 130$, or 78,000 pounds. The distance $l' = 8$ inches, or .66 foot, while the value of l = one-half the height of the wall, or 7.5 feet. Upon substituting these values in the formula $P = \frac{Wl}{l'}$, it becomes $P = \frac{78{,}000 \times .66}{7.5}$, whence P is found to equal 6 864, and the pressure per square foot = 6,864 ÷ 300, or 22.8 pounds, which could only be produced by a great gale. A concentrated force at the top of the wall would more than likely destroy the brickwork at the top of the wall before it would overturn it. The theoretical force necessary to overturn the wall when applied at the top may be readily figured by the same formula as given above, letting l equal the distance from the base of the wall to the line of action of the force.

***

(594) (*a*) What is the best manner of erecting a fireproof vault for a bank? (*b*) How can it be aired if placed in the interior corner of the building? (*c*) Since the vault is to be two stories in height, the lower story being in the basement and the other on a level with the floor above, how can the floor separating the two stories and the roof of the vault be constructed?
J. E. C. D., Montreal, Can.

ANS.—(*a*) The best construction for a fireproof vault is to make the walls of brick. The brick walls should be hollow, that is, they should consist of two walls with a 3- or 4-inch air space between. It is usual, in constructing such vaults, to make the exterior wall about 12 inches in thickness and the interior wall 9 inches. Such vaults are sometimes damp, and are then ceiled on the inside with wood sheathing. Fire experts do not, as a rule, consider such a lining disadvantageous, as wood is an excellent non-conductor of heat and is not combustible when excluded from the air, as in a vault. All fireproof vaults should always be provided with the regulation vault door, 6 or 8 inches thick, made of steel plates, and filled with a fire-resisting cement. The frames of such doors are likewise of iron or steel, and are built in the brickwork. All of the companies who manufacture safes build and keep in stock such doors, which are provided with combination locks. (*b*) There are no means of adequately ventilating such vaults, as openings of any kind would destroy their efficiency. For this purpose a door at each end is sometimes provided where it is possible, though, owing to the size of the vault in question, ample ventilation may be had through the one door. (*c*) The floor between the stories, that is, between the upper and lower vault, may be constructed by supporting thick slabs of bluestone supported on I beams. The stone should be from 4 to 5 inches think. The roof may be made by springing brick arches of short span between the sides of the vault and I beams and filling in over the top with concrete, making the roof about 12 inches thick. The brick arches will be amply strong if made one brick in thickness, or 4 inches, as the concrete filling adds greatly to its strength.

***

(595) I desire to know what cementing material the ancients used in laying tile floors. I have laid a mosaic floor in cement, but it will not stay down; it gradually works up and requires constant relaying. Will you tell me what is the trouble and how I may remedy it?
A. B., Salt Lake City, Utah.

ANS.—While most of the cementing materials used by the ancients have been analyzed and their chemical constituents determined, the actual materials used and the processes of preparation are unknown and they have not been reproduced in modern times. The important feature in all mosaic work is to have a solid foundation of either brick or concrete, without which it is impossible to secure a good job. After the foundation is laid it should be swept clean and well dampened. The tiles should also be soaked in water for some time before they are used. If this

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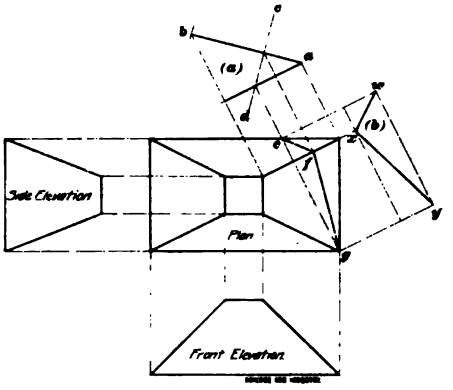
precaution is not taken, the brick or tile will absorb water from the thin layer of cement between them, making it powdery and useless. Only the best Portland cement should be used, the American brands, when fresh, being equal to most of the English. The cement should be mixed rather thin, without sand.

***

(596) Please explain method of finding the correct angle of divergence between the flaring sides of hopper shown in the accompanying sketch.

A. J., Philadelphia, Pa.

ANS.—After completing the plan and elevations shown in the figure, draw an oblique elevation as at (*a*) in which one of the hips of the hopper will be



shown in its true length—that is, *a b* at (*a*). At any convenient place draw the line *c d* perpendicular to *a b* as shown, and project the points of intersection to the plan at *e*, *f*, and *g*. Construct at (*b*) a full view of the foreshortened triangle *e f g* by aid of projectors drawn at right angles to those from the view at (*a*). The angle formed between the lines *w x* and *x y* in the full view at (*b*) then is the correct angle of divergence between the sides of the hopper—in other words, the diedral angle of the two planes.

***

(597) In a recent civil-service examination the following question appeared: "Describe ranging timber and *gullage* foundation." I have heard of grillage foundation and am familiar with this kind of foundation, but have never heard of the other. Will you please enlighten me?

J. H. C., Rochester, N. Y.

ANS.—It is very likely a typographical error and that grillage is meant. There is no such term as gullage used in foundation work.

MISCELLANEOUS

(598) Please tell me (*a*) what an echo is, and (*b*) how it gives two or more repetitions in some places and only one in others.

J. R. B., Providence, R. I.

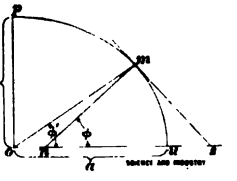
ANS.—In classical mythology, Echo was an oread or mountain nymph belonging among the attendants of the goddess Juno. Having given offense to her mistress by an irrepressible habit of monopolizing the conversation, she was punished by being rendered incapable of speech before another had spoken, and incapable of silence afterward. Shortly after this misfortune she fell in love with a beautiful youth named Narcissus, but being handicapped in the matter of speech, she was unable to let him know of the state of her affections, and in consequence pined away until only her voice remained. Even yet, her voice, full of sadness and melancholy, may often be heard in lonely places among hills and mountains. Such is the myth. Admirably appropriate, therefore, is the application of her name to a phenomenon in acoustics. The modern meaning of the term is as follows: "An echo is a sound given back from an opposing surface and returned to the source of the sound." (*b*) For an echo to be heard more than once, two or more reflecting surfaces must be opposed to each other. Thus, if a man standing in a valley between two vertical cliffs that exactly face each other were to utter a loud shout it would be reflected back and forth many times and be heard as an echo until its intensity was reduced below the limit of hearing. The writer knows of a spot on a high bank along the Susquehanna where one may stand and hear an echo repeated in this manner. The echo is caused by similar high vertical banks on opposite sides. The rolling reverberation of thunder is nothing but a repetition of sound by reflection from cloud banks. If thunder could occur when the sky is perfectly clear and the earth's surface below is without hills and valleys, the sound would be single and clean-cut, very much like the report of a rifle. When there is only one reflecting surface, there can be only one reflection and therefore only one echo.

***

(599) (*a*) Where can I procure and what are the prices of "Chambers' Mathematical Tables" and "The American Ephemeris and Nautical Almanac"? (*b*) How is geographical latitude reduced to geocentric latitude? (*c*) Are there any tables for deducing longitude and latitude from right ascension and declination?

B. D. P., Dunmore, Pa.

ANS.—(*a*) "Chambers' Mathematical Tables" and "The American Ephemeris and Nautical Almanac" may be obtained through The Technical Supply Co., Scranton, Pa. The price of the former is $1.75 and of the latter, $1.25. (*b*) Referring to the accompanying figure, the *geographical*, or *geodetic*, latitude of any place *m* is the angle ϕ subtended by the line *o u*, representing the plane of the equator, and the line *m n* drawn from the place perpendicular to the tangent *m s* of the standard spheroid; the *geocentric* latitude of the same place is the angle ϕ' at the center of the earth. In order to reduce ϕ' to ϕ, the following formula may be employed: Tan $\phi = \frac{b^2}{a^2}$ tan ϕ, where *b* represents the polar radius and *a* the equatorial radius of the earth. Inserting the value of *a* and *b* according to the latest estimation of these quantities, we get tan $\phi' = 0.993$ tan ϕ, which formula shows that ϕ' and ϕ do not differ very greatly, the difference between them in latitude 45° amounting to not more than 11′. (*c*) We are not aware of the existence of any such tables.



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(600) Please inform me where I can get mica ground very fine, and what firm is manufacturing machinery for this purpose.

P. W., San Diego, Cal.

ANS.—W. H. Whitaker, 245 Front St., New York, is a large dealer in ground mica, and he would probably be able to give you information concerning the machinery for this purpose. The mica is ground wet, sized hydraulically, and then dried.

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(601) (a) Why is it that an incandescent electric-light globe does not sink in water, there being no air inside to support it? What are (b) cross-section paper and (c) profile paper used for, and how are they used? C. V., Philadelphia, Pa.

ANS.—(a) What keeps a hollow glass globe from sinking is not the pressure of the air within, but the buoyancy, or upward pressure, of the water. Of two equal globes, one empty and the other filled

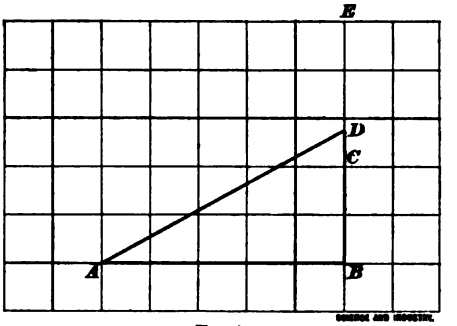

FIG. 1

with air or any other material, the latter weighs more and has a greater tendency to sink. The law governing phenomena of this kind is known as *the principle of Archimides*, and is stated thus: *Any body placed in any fluid loses a part of its weight equal to the weight of the fluid displaced.* If the weight of a volume of the fluid equal to that of the body is greater than the weight of the body, the body will float. (b) Cross-section paper, also called *squared paper*, is paper ruled into squares, as shown in Fig. 1. It is very convenient for drawing figures to scale, and specially for making sketches. Suppose that the side of each square in Fig. 1 is ¼ inch, and that we wish to draw, to a scale of ¼ inch to the foot, the hypotenuse of a right-angled triangle whose sides are 10 feet and 5 feet 6 inches. Starting at any convenient corner *A*, we lay off 5 divisions to *B*; then will *A B* represent the 10-ft. side of the triangle, since each division, being ¼ inch, or ⅛ inch, represents 2 feet. Starting from *B* we lay off on *B E* 2 divisions to *C*, which will represent 4 feet; and since 1′ 6″ is represented by ¾ of a division, we lay off *C D* (estimated by eye) equal to ¾ of a division. Then will *B D* be the 5′ 6″ side of the triangle, and *A D* will be the hypotenuse. In cross-section paper, every fifth or tenth line is usually made heavier than the others. The advantage of this method of subdivison is manifest. (c) Profile paper is paper ruled as shown in Fig. 2. It is mainly used for plotting level notes and showing "profiles" (that is, side views) of road and sewer lines, and the like. The horizontal and the vertical scale are not the same in this kind of work. Generally, elevations on the ground are taken to tenths of a foot, and the distance between every two of the fine horizontal lines is taken to represent .1 ft. The vertical distance between two horizontal medium lines (as *M N* and *P Q*) represents, therefore, .5 ft., and the distance between two heavy lines, 2.5 ft. The horizontal scale depends upon the length of the line whose profile is to be shown. In the figure, we have taken the distance between two of the heavy vertical lines to be 100 ft. The distance between two of the fine vertical lines is therefore 10 ft. Elevations are referred to any assumed plane, called a *datum plane*. Suppose that we assume the line *A B* to be 100 ft. above this plane, and that the elevations of the points 0, +20, +40, +60, etc. are 108, 103.8, 104.6, 103.7, etc. Laying off to scale on the vertical lines through the points 0, +20, etc. the distances 8 0, 3.8, etc., we obtain the points marked in the figure, and a wavy line drawn through them is the required profile.

***

(602) What books on the Differential and Integral Calculus do you consider good for a beginner? Please give prices, and state where the books can be obtained? J. O. W., Valla Hemnies, Norway.

ANS.—There are hardly any books on the calculus that are entirely suited to beginners. This is a subject the underlying principles of which are seldom stated with sufficient clearness by writers of text-books. The books that are likely to give the least trouble to the beginner are Todhunter's "Differential Calculus," $2.60; the same author's "Integral Calculus," $2.60; and W. S. Hall's "Differential and Integral Calculus," $2.25. Any of these works can be ordered from The Technical Supply Co., Scranton, Pa.

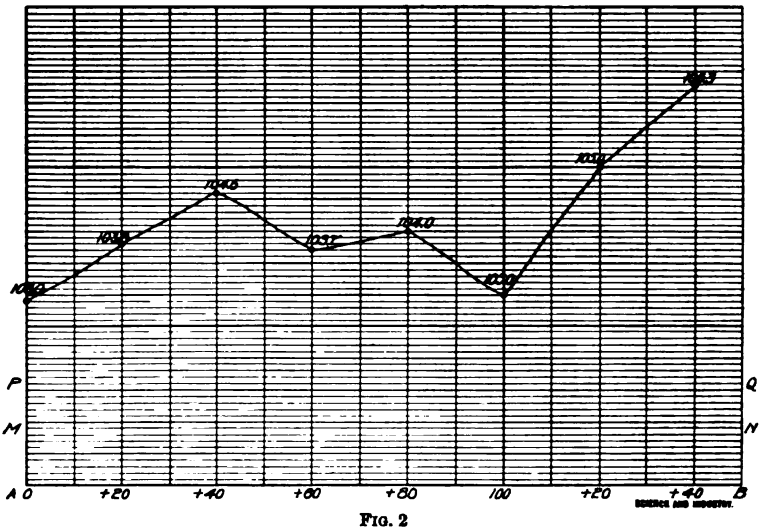

FIG. 2

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(603) What is the process to reclaim rubber from waste material, such as old hose, sheet rubber, packing, etc.? W. R. H., Yonkers, N. Y.

ANS.—We are not acquainted with any process for reclaiming rubber. We are under the impression that old rubber such as you mention is used to a considerable extent for making the cheaper grades of hard rubber articles, but do not know how it is done. Perhaps some reader will inform us.

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THE INTERNATIONAL CORRESPONDENCE SCHOOLS, SCRANTON, PA.

HINTS ON HOW TO STUDY

1. *Beginning the Study of a New Subject.*—In beginning the study of a new subject, pay particular attention to the terms that are defined until you are thoroughly familiar with them and understand them at a glance.

2. *Do Not Study Too Much at a Time Nor Too Long.*—You should not study longer than an hour or an hour and a half at one time, because if you do, your mind becomes confused, and you will be unable to reason clearly.

3. *Write Your Impressions of What You Study.* It will help you to remember what you have studied if, after studying it, you write down in your own words the ideas you have received, just as if you were trying to explain to some one else what you have learned. This will not only help you to remember what you have studied, but will also aid you to arrive at a better understanding of the subject, and will enable you to express your ideas in writing. Do not be discouraged if your first efforts at writing are not entirely satisfactory; the more you practice, the better you will write and the more accurately you will express your ideas.

4. *Devote a Certain Amount of Time Each Day to Study.*—Even though you may not be able to devote more than quarter or half an hour each day to study, you will make surprising progress.

5. *Think Over What You Have Studied.*—You will make more rapid progress by thinking over, while at work or in leisure moments, all that you have studied the preceding day, as the mind works more clearly when one does not have the book before him. Carefully consider the difficult points, and go over in your mind all that you can recollect. You may not be able to remember everything, but this practice will both fix things in your mind and also show you what parts you ought to study still more.

6. *Be Thorough.*—You should not expect to understand all that you study, in going through a paper for the first time. The best way is to study a few pages and try to understand the information there given. It sometimes happens that, when there are certain statements or operations you do not clearly understand, it is better for you to pass further on into the subject, where you are likely to find applications of the points not understood, and these practical applications will clear up the matter very materially. Always be sure that you understand a subject thoroughly before taking up the next one.

7. *Make Haste Slowly.*—Do not try to study too much at one time; you will accomplish more in a given time than by hurrying through the subject without half understanding it, because, unless you really understand the subject, you will meet with difficulties further on, and will be obliged to stop and review what has gone before.

8. *The Most Valuable Knowledge is That Acquired by Your Own Efforts.*—As we have often shown in these pages, some of the greatest scholars of the age learned by themselves. Such men would have considered our Schools a great aid. Though most students cannot master a subject without help, nevertheless, they should seek assistance as little as possible.

9. *Review Frequently What You Have Studied.* After having gone through a subject, and obtained a fair knowledge of it, review it very thoroughly. During the review, work out all those things that you could not understand when you went through it the first time. A review of two or more subjects back will often clear up points that could not be understood at the first studying or the first review.

10. *Learn to Rely Upon Yourself.*—When you are working out examples in actual practice, you are obliged to rely entirely upon your knowledge and upon the accuracy of your calculations. The importance is apparent, therefore, of cultivating a spirit of self-reliance while you are studying. The men who are looked up to and who forge ahead in practice are those whose self-reliance makes others depend on them. Such men always attain this quality by careful study, either of books or of facts and processes themselves. The suggestions given here will enable you to cultivate a spirit of self-reliance in your study that will continue when you get into practical work.

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THOUGHT APPLIED TO WORK

"Books are white paper, unless men spend in action the wisdom they get from thought."—*Bulwer.*

Have you noticed the tendency of progressive manufacturers to place over the men in a department, or in charge of important machinery, young graduates of technical schools? Such young men, after a period of earnest work, master the situation and forge far ahead of the other men. For years before they came to the shop they studied, day and night, the experience of others as written down in books, and are now enabled to advance because they can "spend in action the wisdom they get from thought."

But with all their knowledge they were helpless, until they had shop experience.

You, however, who are in a shop, mine, or place of business, already have experience. Now learn the principles of your work, and qualify yourself to take the place that will otherwise be given to a younger and better-educated man.

Spend two years and $40.00 on our Complete Mechanical Course and you can take a foreman's or superintendent's place.

Fifteen months' study and $28.00 expense in the Mechanical Drawing Course will fit you for the drafting office.

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Six months' study and $10.00 investment in the Wiring and Bellwork Course will give you a profitable business, if you live in a fairly large town.

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Thirty months' study in our Complete Coal Mining Course will qualify you, at an expense of $42.00, to pass any mine-law examination and take the position of foreman or superintendent of a coal mine.

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MAKE MONEY IN SPARE TIME

Teachers and students who have Saturdays and part of every afternoon to themselves could make profitable use of the time. Agents and canvassers sometimes have days or weeks in which they can do little or no canvassing. Steel workers on night shift sleep part of the day, and could make use of the rest. Miners finish their work before the day is over, and also experience periods when the mines do not work full time. Many laborers of intelligence could utilize idle days if they knew how to do so. Farmers' sons and daughters have many hours that they could put to some profitable employment. *Thousands of people have spare time they would like to make count toward increased incomes.*

If such persons will take a Course of study in Surveying and Mapping, *by mail*, they can do surveying in odd days or hours.

Some should study Electric-Light Wiring and Bell Work, and qualify themselves to do jobs in wiring houses and shops for lighting or electric bells.

Others can study Lettering, and add to their incomes by making the price cards and window cards for local stores.

Those who will study Chemistry can earn considerable money by performing chemical analyses for merchants, physicians, coroners, or manufacturers. The fees in such work often amount to large sums of money.

Mechanical or Architectural Drawing can easily be learned *by mail*, and the resulting skill applied in making Patent-Office drawings for inventors, drawings for small shops, or plans for carpenters, contractors, and builders, or for persons who expect to build.

Many can study Bookkeeping, and then in odd hours keep the books for one or more small concerns.

A knowledge of Stenography will equip others with the means of helping business, professional, or literary men in their vicinity, and at the same time helping themselves.

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The Complete Architectural Course will educate them for positions as architects, in which capacity women have achieved notable successes.

Graduates of the Mechanical Drawing Course can secure positions in the drafting rooms of shops and manufactories.

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The Course in Telephony will enable progressive women to begin at the operator's desk and push themselves into good positions in the rapidly-growing business of telephony.

The Complete Chemistry Course fits students to perform all kinds of chemical analyses and then to secure positions as professional chemists or to teach chemistry in high schools or academies; it is indispensable to a woman who intends to become a drug clerk.

The Courses in Lettering enable saleswomen to secure the best places in retail stores.

The Business Courses open the way to positions as bookkeepers, stenographers, amanuenses, private secretaries, etc.

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As I was ambitious to become a stenographer, I enrolled in the Complete Stenographic Course. It is so clear and concise that any person who is willing to study cannot help but learn. A short time after I received my Diploma, I was offered a position in the office of the Lanyon Zinc Company, of this place, at a fair salary, with an increase of wages after I had acquired some experience. I at once accepted the position and am getting along nicely.

MARY WILSON, Iola, Kansas.

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The great impetus recently given to all technical trades and professions, by the commencement of a new era of commercial prosperity, has forcibly brought to the attention of the public the great value of technical education, acquired simultaneously with practical experience. The graduate of the ordinary technical university is obliged to accept a minor position in his profession, and trust to his education for rapid advancement. But the ambitious mechanic can make immediate application of the knowledge acquired through our instruction, and secure, in the shortest possible time, a lucrative position.

The various technical colleges are open to but few. Our Schools are open to all. The International system fully meets the requirements of ninety-five per cent. of the people, by supplying the education for which employers are willing to pay, and *pay well*.

Why do we pray to heaven without setting our shoulder to the wheel.—*Carlyle.*

GREAT VALUE OF OUR COURSES

We agree with all on the value of experience. The more one has, the better off he is. But every one must admit that there is plenty of valuable experience he has never had, nor would it be possible for him to obtain more than a small portion of it during his working lifetime. Successful men seldom work out for themselves the rules and formulas they use in their work. They haven't time; so make the best use of other men's experience, and their successes or failures become, in turn, precedents to be followed or avoided by others.

This is where the great value of our Courses lie. They represent the united experiences of the best men in each business. They are made up of tried and proven facts, formulas, and processes, boiled down, put in every-day language, freely illustrated, and presented to the student in orderly, systematic, step-by-step Courses of instruction, that contain more experience than one man could get alone in half a dozen lifetimes.

Our instructions on the practical applications of a single scientific truth may save any one months of experimenting, and give him just so much time to learn the experience of others.

A NEWSPAPER CLIPPING

We clip the following from the "New Berlin (N. Y.) Gazette" of October 28:

"Architect D. M. Collier, who passed the state examination April last, after devoting part of his time to state work since that date, has decided to accept a lucrative position with State Architect G. L. Heins, in the state capitol at Albany, and will therefore discontinue his office practice here.—'Oneonta Star.'

"Mr. Collier is a Pittsfield boy, and deserves his success. Specimens of his work in this village are the new residences of E. H. Elliot and Abram Brown. He is a graduate of The International Correspondence Schools, of Scranton."

That one man should die ignorant who had capacity for knowledge, this I call tragedy.—*Carlyle.*

The element of difficulty is the very core of all progress. The best path is not the easiest either to find or to tread; but once found and once trodden, who would retrace his steps?

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SCIENCE AND INDUSTRY

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NEVER GIVE UP

Be Persevering.—Perseverance is the golden key which unlocks the treasures of success. Many without it have given up at just the moment when their efforts were about to be crowned with success. Many others, when disaster stared them in the face, have stemmed the tide and come off victorious. In the long run, genius, if united to indolence, and working only by fits and starts, will be distanced by the plodder. Do not become discouraged because you think you are not advancing as rapidly as some other student. He may have had some previous knowledge of the subject, or he may have more time to study. Never be discouraged. What you cannot understand one night may be clear the next. Do not imagine that because you do not make rapid progress you are not advancing, for the very difficulty upon which you are at work may be all that stands between you and an easy grasp of many succeeding pages. Remember that thousands of men with no more education than yourself and no better opportunities for study have solved the same problems you find so difficult. Remember that we stand ready to help you and that you cannot exhaust our patience. We take the greatest pains with backward students when they give us an opportunity to help them. Our best friends and strongest endorsers are those students with whom we have had the greatest trouble. Many have been taught arithmetic who could not do the simplest problem in addition when they joined. Even if a dull student does progress slowly, it is only a question of time, if he perseveres, until he completes the same studies as the bright one. Some of the best work now done in our Schools is performed by students who considered themselves too dull to learn anything when enrolled, but who have learned that keeping everlastingly at it brings success. Many, always shy, shrinking, and backward in classrooms, make wonderful progress with us. What others have done and are doing, you may do.

Be Judicious.—Do not try to study when tired. Ten minutes spent on a problem, when the mind is in condition to work properly, is worth more than three hours when the mind is exhausted.

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Be Practical.—To every-day life, try to make use of, or apply as much as possible of, what you have learned to life's actual concerns.

"The only valuable kind of study," said Sydney Smith, "is to read so heartily that dinner time comes two hours before you expect it; to sit with your Livy before you and hear the geese cackling that saved the capitol, and see with your own eyes the Carthaginian sutlers gathering up the rings of the Roman knights after the battle of Canne, and heaping them into bushels, and to be so intimately present at the actions you are reading of that, when anybody knocks at the door, it will take you two or three seconds to determine whether you are in your own study or on the plains of Lombardy, looking at Hannibal's weather-beaten face and admiring the splendor of his single eye."

The tortoise in the right road will beat a racer in the wrong. It matters not, though a youth be slow, if he be but diligent. Quickness of parts may even prove a defect, inasmuch as the one who learns readily will often forget as readily; and also because he finds no need of cultivating that quality of application and perseverance which the slower student is compelled to exercise, and which proves so valuable an element in the formation of every character. Davy said, "What I am I have made myself"; and the same holds true universally.

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SCIENCE AND INDUSTRY

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SUCCESS THROUGH GOOD USE OF TIME

The man who cannot find time to improve his mind and his opportunities by study, should consider the object lesson taught by the success of the five men whose letters appear herewith.

Any one who has lived in the country will appreciate the disadvantages under which Mr. Mischler labored: exhausting work in summer; limited advantages in winter; then an apprenticeship; and finally long hours at the bench in the wood-working trade. If, under these discouraging circumstances, he had not found time, taken it, fought for it against the natural longing for rest and recreation, he would be still where many readers of this are—at the bench, with little prospect of advancement.

Those who possess the ability to direct the work of others, should bring it to the front. This ability, as utilized in the positions of foremen, superintendents, and managers, commands the highest salaries, whatever the kind of work. The man who has it in him, should fit himself for a position in which he can use it.

FROM BENCH TO ASSISTANT FOREMAN

Previous to enrolling in the Complete Architectural Course, I had only a common school education, as I worked on the farm in the summer and went to school in the winter, until I began to learn my trade. I cannot help but feel that the Course has been of benefit to me, as it has been the means of my promotion from the bench to Assistant Foreman of the largest architectural wood-working manufactory in this section, and my wages have been raised twice.—WM. S. MISCHLER, 796 Broadway, Albany, N. Y.

Many readers will wonder how Mr. Terry was able to push to the front. It was by developing his powers through education. If they also will systematically sacrifice time now devoted to what brings no return, present or future, they can accomplish exactly as much as Mr. Terry has done. They can make up their minds, also, that, without some sacrifice of present ease, they can never accomplish anything of the kind.

Mr. John Moore took a little time daily to add to his experience knowledge of mathematics and skill in mechanical drawing. No reader but has as much time as he had. It would be absurd to ask any one whether he desires similar rewards; everyone wants advancement. But it cannot be had without work. It can be obtained only by taking the time and making the effort necessary to deserve it. Time should be utilized for study, now and then, whenever a spare moment comes. It should be taken regularly every day. The main thing is to be sure it *is* taken. The reward can soon be expected.

IN CHARGE OF DRAFTING ROOM

When I enrolled for the Complete Mechanical Course, I had very little knowledge of mathematics or mechanics, and was doing plain drafting, at ordinary wages. Since enrolling, my wages have been raised three times, and I am now in charge of the drafting at a large machine shop, with the ability to direct others in the work, as well as to design machine parts. I am also teaching the mechanical-drawing classes in the evening school of this city.—WM. C. TERRY, 12 Meadow Street, N. Adams, Mass.

Those who live on the line of an electric street railway know what a conductor's hours of work are: in many cities, including stops and lay-overs, from twelve to sixteen hours to make up a working day of ten hours. What time has a conductor for study? Yet many conductors are finding time for study, to advance their interests. Mr. Sweetman is an example of one who took time when most men would have said there was no time to take. His use of extremely limited spare time has brought him a return of shorter hours, safer and less exposed work, two promotions, and the corresponding raises in salary. If he could

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do this while working as a street-car conductor, what cannot the average mechanic do, with much shorter hours of labor and greater opportunities for study?

Who would not like to increase his salary by half, to rise, moreover, from common labor to a responsible, well-paid position? Mr. Hightower has done it. Others have done it, by thousands. Any one can do it who will set to work with a will, and devote what time he has to making himself proficient in his work. There is no limit to what can be accomplished, given determination and time. A quarter or half an hour, one hour, two, three per day, will soon put one years ahead of what he is now. Many a man who has a good "head" now, can make his ability tell far better by merely filling his mind with systematic information regarding what other successful men have found good practice. Men willingly spend eight, ten hours a day at work, training hands and eyes to manual dexterity. They ought also to spend an hour or two training that which controls hands and eyes — their minds. It is a waste of opportunity to spend all one's time on that which brings only a moderate present return and promises little for the future. Most men should rest less; shorten their recreation hours; study more; invest time daily in brains; make this a habit. They can then confidently expect and ask for what they desire now but cannot get—shorter hours, more attractive work, more responsible positions, and better salary.

Good fortune comes only through good work. "Half the people of America," says President Jordan, of Leland Stanford, Jr., University, "believe this is a world of chance. Now and then some man catches a falling apple, picks up a penny from the dust, or a nugget from the gulch. Then his neighbors set to looking into the sky for apples, or into the dust for pennies, as though pennies and apples came in that way. Waiting for chances never made anybody rich. Whatever is worth having, comes because we have earned it. There is but one way to earn anything—that is, to find out the laws which govern production, and to shape our actions in accordance with these laws. Good luck never comes to the capable man as a surprise. He is prepared for it, because it is the very thing he has a right to expect. Sooner or later, every man finds this out."

FOREMAN PATTERNMAKER

It was while working at my trade as pattern-maker that I saw my great need of an education. Hearing of your Schools, through one of your students, I at once enrolled for the Mechanical Drawing Course. As a result, I have now been advanced to the position of foreman of the Patternmaking Department at the Oil City Boiler Works, and my wages have been raised $12.00 a month. I cannot give The International Correspondence Schools too much praise.—JOHN MOORE, 7 Myers Street, Oil City, Pa.

CONDUCTOR TO CHIEF ELECTRICIAN

I owe so much of my success to the Schools that I, with great pleasure, state a few of the practical results brought about by my Electric Railways Course. I was acting as conductor on the Guelph Street Railway when I enrolled. Having a desire to advance, I set to work with a determination, and was soon promoted to assistant electrician, and afterward to chief electrician, which position I now hold. Each promotion brought me an advance in salary.—J. H. SWEETMAN, 76 Northumberland Street, Guelph, Ont., Can.

SALARY INCREASED FIFTY PER CENT.

While working as cleaner in one of the largest hotels in Toledo, the chief engineer of that building advised me to enroll in your Schools. I accordingly took up the Stationary Engineers' Course, and am now employed as Engineer, and earning 50 per cent. more wages. What I have learned is worth all the time I spent in study, besides the nominal cost of the Scholarship. I heartily recommend the Schools to persons deprived of the chance to get an education while young.—T. DOUGLAS HIGHTOWER, 383 Indiana Avenue, Toledo, Ohio.

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VALUE OF THEORY TO THE ENGINEER

The successful engineer must master the theory or science of his profession. It is of the utmost importance for all, no matter how much practice they have had, to understand this "organized common sense" of their work, as Sir W. H. Preece calls it. "It is not a question between science and practice," said he, in a recent address before Scottish engineers, "it is a question between science and rule of thumb. Practice is always there, but rule of thumb means rule of error, until by repeated failures rule of thumb becomes rule of right, which means the victory of organized common sense. Organized common sense is a very good term for science. Scientific men talk nonsense when they observe differences between science and practice; and so-called practical men act foolishly when they ignore science and assert that an ounce of practice is worth a ton of theory. Practice based on true science means immediate success and economy; practice based on rule of thumb means error, delay, and excess of cost. The engineer cannot neglect the laws of nature any more than the scientific man can ignore successful practice."

"FROM FIRE-SHOVEL TO INDICATOR"
Hiram McGlaughlin, Operating Engineer for the Union Bag and Paper Co.

To the thorough mastery of theory every engineer of note owes his advanced position. This is true in every branch of engineering — civil, mechanical, electrical, and steam. An engineer's progress often dates from the very day when he began to improve his efficiency by the study of theory.

A case in point is that of the operating engineer of the Union Bag and Paper Co., Mr. Hiram McGlaughlin, who says, speaking of his own success and its causes: "I had been for twenty-two years in the employ of the firm whose Watertown, Mass., mill was bought out last March by the Union Bag and Paper Co. A few months later I was at my desk in the engine room working out problems connected with my studies in your Schools, when there stepped in a man who said he was the manager of the company's mills. He sat down with me and wanted to know how I was spending my time. I told him the whole story. He asked for my standing in your Schools; I gave it to him, and he went away.

"Two weeks later I was invited with him to our Sandy Hill, N. Y., mill. Since that time I have been his consulting engineer for all of the fifteen mills. He said this: 'When I find a man of your age still studying to make himself valuable to his company, he is the man I am looking for.' He uses me finely, and quotes me on all occasions as authority on steam.

"My Course in Stationary Engineering has been and is now the one step in my life's work that has enabled me to see through the many intricate problems connected with my profession. I can now see plainly what before I only saw as through a mist, dimly. I owe my recent success to my high standing in your Schools."

It is an encouragement to students of engineering to know that Mr. McGlaughlin's experience is, by no means, an uncommon one. A progressive engineer, who makes the effort necessary to master the theory of engineering, is certain to rise.

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FARMER BOY TO IRON-WORKS OWNER

ROBERT ALLISON, PROPRIETOR OF THE FRANKLIN IRON WORKS

"The roughest road," says Benjamin Franklin, "often leads to the smoothest fortune." Most successful men of today can look back to the beginnings of their careers with a pardonable pride in the determined struggles that they had to make to raise themselves from the early disadvantages of poverty and lack of education. Those who are born to work are often fortunate. They take up the yoke in their youth. They set their faces to duty from the first; and if life should prove a burden, their backs become inured to it, so that they bear the weight more easily than others. But the discipline of the effort to escape from unfavorable surroundings is exactly what is required to develop the traits of character most essential to success.

Robert Allison, the subject of the following sketch, was born in Middleton, Durham County, England, Dec. 25, 1827, and came to this country with his parents when eighteen months old. The family settled in Schuylkill County, the coal business then being in its infancy. When Robert was about thirteen years of age, the family removed to Shamokin, Northumberland County, and soon after moved to a farm near Shamokin. It was here that the boy Robert first developed a talent for mechanical appliances. A small stream of water ran through the meadow; on this stream he erected a dam and made with crude tools consisting of saw, hatchet, plane, etc., a complete sawmill in miniature. Although this mill would not saw timber—not having sufficient power—all the motions were complete, from the waterwheel to the feeding of the log to the saw and the return of the carriage after making the cut. This little sawmill was the wonder of the natives, and attracted no small attention from the townspeople and visitors to the neighborhood. Unfortunately, the facilities for education were extremely limited, the country schools being open but a few months during the winter, the teachers being farm hands who did farming during eight months of the year and teaching school the other four months. Under these conditions, boys in Robert's circumstances were kept at work in and about the mines and farm for at least eight months of the year, and went to school the other four months, the branches taught being the three R's.

Mr. Allison's first experience with real machinery was when he was about fifteen years of age. At this time he was appointed assistant engineer at the Shamokin furnace. This developed a further interest in machinery, and at the age of sixteen he was apprenticed to the firm of Haywood & Snyder, Pottsville, Pa., to learn the trade of machinist. After completing his apprenticeship he worked as a journeyman for about two years, when he accepted the position of foreman in the shops of T. H. Wintersteen, Port Carbon, Pa. During his service with Mr. Wintersteen he introduced and developed many improvements in the shops, one in particular being a tool for boring car wheels, this machine doing five times as much work as the old way. Another innovation was a portable machine to bore large cog wheels, spiders, etc., the system employed reducing the cost to at least one-half in fitting those large pieces of machinery. A paper entitled "The Old and the New," presented by Mr. Allison at the Detroit meeting of the

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American Society of Mechanical Engineers, in June, 1895, and published in Vol. XVI of the Transactions, gives an interesting outline of the difficulties that beset the machinist of those days.

About 1863, Mr. Allison, in partnership with F. B. Bannan, of Pottsville, started the Franklin Iron Works, of Port Carbon, which had been idle several years. The works, under the personal management of Mr. Allison, immediately rose into prominence, and, in connection with the inventions of Mr. Allison, established a world-wide reputation. One of the first and most important inventions was the Allison Cataract steam pump. This pump revolutionized the system of freeing the underground mines from water. Another important invention was the hydraulic feed for diamond drilling machines. The diamond drill was a French invention, and was introduced here in a very crude state. Mr. Allison was induced by the Pennsylvania Diamond Drill Co., who had purchased the French patent, to take hold of the machine and develop it. His invention of the hydraulic feed was the stepping stone to its success, and made it what it is today—the greatest prospecting machine in existence.

In 1878, Mr. Allison purchased Mr. Bannan's interest in the works, and has operated them alone until within two years; the active men in the works now being C. K. Allison and F. C. Allison, sons of Robert Allison.

Among the inventions of Mr. Allison, and exploited at the Franklin Iron Works, may be named various improvements in rock drills and air compressors, and a new shaft governor for high-speed engines, etc.

The Franklin Iron Works, under Mr. Allison's management, have been eminently successful, both mechanically and financially, and stand today as an incentive to young men of limited education and means, and shows what can be accomplished by energy, strict attention and application of the mind to the work in hand, fair dealing, and a determination to fulfil every obligation entered into.

Franklin Iron Works machinery has been extensively used in Australia, Nova Scotia, Sandwich Islands, and other foreign countries, and in almost every state in the Union.

Notwithstanding Mr. Allison's extensive business transactions, he has always found time to take an active part in public affairs. He was for many years president of the Board of Trustees of the State Hospital, at Ashland, Pa., and is now trustee of that institution; he is president of the Port Carbon school district, treasurer of the local Electric Light Co., president of the Pottsville Gas Co., a director in the Pottsville Water Co., a director in the Schuylkill Trust Co., a member of the local committee of the State Board of Public Charities. His connection with the institutions named shows that his advice and assistance are appreciated where he is best known, and emphasizes the fact that, no matter how humble a beginning, the way is open to all.

Mr. Allison is a strong believer in technical education for young men. Speaking of this he says: "I consider a technical education almost indispensable to the success of a young man who wishes to enter any mechanical or engineering profession. In connection with this education, a desire and determination to succeed will, in a large measure, contribute to his advancement.

"I consider the advantages of young men today as far superior to the advantages to be had at the time I entered my career, both as to facilities and cost. Any young man, with the ability and desire to pursue a mechanical calling, can, after passing through our public schools, take a course in any of our numerous technical schools and prepare himself to enter the field. If not able to take a course in a high-grade institution, the correspondence schools are open to him at a nominal cost. In my day these sources of help were scarce, and all through my career I felt the want of a technical education, and had to substitute hard knocks and horse sense.

"I attribute my success largely to the fact that I naturally took to mechanical pursuits, and, when a difficult problem confronted me, I generally found a way to work it out; then I made it a rule to do the very best I could, no matter how simple or how complicated the job that came into my hands. I also gave my personal attention to all the details of the work in hand, and made it a point to fulfil all promises to customers, as to strength and capacity of machinery, and delivery of same, and, when I failed at any point, which was seldom, I always applied the remedy at my own cost. In this way I established a reputation that brought business without solicitation."

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The secret of the success of Mr. Allison and of every other man who has worked his way from poverty to affluence is that he applied himself to legitimate business early and late, ignoring all outside business and sticking closely to his purpose. "Constancy to purpose," says William Drysdale, "is almost a miracle-worker." Rarely does a young man reach his majority without an opportunity to see this for himself. A boy sets his heart upon some object that seems altogether beyond his reach. He has no money, his parents and friends have no money to spare for him. But if he fully makes up his mind to it, it is sure to come. Every dime saved, every dime earned, brings it nearer. No temptation can induce him to spend his little hoard, because he has a single object in view. If he has real constancy to purpose, he overcomes poverty, one of the commonest and most difficult obstacles, and accomplishes his purpose.

Let every man remember, also, that rising in life is not a rapid process. To realize this will save him from many a discouragement, and inspire him with appreciation of the importance of the little steps that lead to success. In the words of Longfellow,

> We have not wings, we cannot soar;
> But we have feet to scale and climb,
> By slow degrees, by more and more,
> The cloudy summit of our time.

EDUCATION THE KEY TO SUCCESS

Every man has found the key to success when he has learned how to use the qualities of his mind to the best advantage.

With a trained mind he is able to use every power and faculty as well as it is possible for them to be used. The privileges of the educated are inestimable. They know more, feel more, see more, accomplish more, and live more happily than the uneducated. Would you have this world beautiful? Learn what beauty is, and you will find it everywhere. Would you enjoy a higher life? Learn what are the higher things, put your learning to profit, and you will breathe a purer, freer, and better atmosphere. You can, if you wish, make the end of your education to be the raising of your life higher, and rendering it nobler, better, and happier.

You can turn your education to the improvement of your material surroundings. "It makes little difference," says F. Marion Crawford, the noted novelist, "what the trade, business, or branch of learning. In mechanical labor or intellectual effort the educated man is always superior to the common laborer. One who is in the habit of applying his powers in the right way will carry system into any occupation, and it will help him as much to handle a rope as to write a poem." Experience alone can go so far and no further. To bring out the best efforts of the mind requires something more than experience; it requires education. When education is sufficient to enable the mind to understand the hidden principles of natural law, then the man begins to use his abilities to the very best advantage.

Men do not now grapple with their surroundings with their muscles, but with their brains. Every man is trying to make his head save his hands. It is not manual skill that is required of the rising workman as much as it is mind training. Professor B. S. Kimball, of Cornell University, tells us that the manual skill required of the machinist is not nearly as high as that of thirty years ago. The machines that the machinist now has to make are more complicated than those of any period, but the tools furnished him to make them with, are vastly superior to those ever in use, so that the parts of complicated and delicate machinery can be made more easily and cheaply, with less skill on his part. The man of little skill turns out fine work in great quantities by means of turret tools, planers, drills, and other labor-saving devices.

The man who is careless of his future stays at his planer from day to day, forgetful that the revolution of machine-shop practice now in progress is going to land him at the level of a common laborer, unless he masters the principles of his trade and qualifies himself to take positions of responsibility. Otherwise he will not have to wait long before his present companion at the bench, who is improving his opportunities, will be issuing directions for him to follow, and his own chance for advancement will be so much less.

Education is the hope of every ambitious man in the engineering trades and professions. Through it he can accomplish the great thing of making himself necessary in his position. He can prove to his employers that their interests are safe in his hands and that they have not got a mere hireling in their service. "The rising man," says E. J. Hardy, "is

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one who attracts attention by doing something exceptional and beyond the range of his special department." How is it possible for a man to do something exceptional in mechanical work, wherein eminence is attained only through thorough knowledge of theory, unless he takes time to learn that theory?

Education, therefore, is the key to success in the pursuits followed by most readers of this publication. There is a homely rhyme emphasizing this idea that every reader should fix in his mind:

> Education, the capital of mind,
> Success without it will be hard to find,

and every reader who puts in practice the principle suggested can be assured that with a little self-reliant effort he is certain to reach the goal of success.

SUCCESS OF COUNTRY-BRED MEN

It is too much the habit for city dwellers who passed their boyhood in the country to consider their early surroundings a serious disadvantage in the struggle for position and success. We wish the many readers of SCIENCE AND INDUSTRY who reside in the country or in rural villages, and the still larger number who live in the cities and can look back to an early life in the country, to realize that this is a wrong attitude to take.

The young men most likely to be successful are those who are resourceful and self-reliant in emergencies. Country life affords unsurpassed opportunities for developing these traits of character. It is not so much what a man knows as what he can do that counts for success; knowledge can be gained at any time, but the qualities of promptness, thoroughness, and self-reliance are seldom acquired after youth.

The kind of life that will produce the highest development of both mind and body is that which gives the mind the most things to think about and the body the greatest number of things to do. In this respect, country life far surpasses that in the city. Life in the country is full of emergencies that must be promptly met. Its experiences comprise greater variety and include a wider field than those that confront the city boy. Dr. Stanley G. Hall, President of Clark University, says that the farmer boy has to know about seventy different industries. Follow a country lad's work and see how the most exacting tests arise continually to tax his ingenuity and skill. The simple operation of plowing is a good example. "He begins plowing, but the plow persists in penetrating the soil too deeply, and he must stop and carefully adjust the plow beam; the mold board is rusty, and he must devise a remedy; the plow strikes a stone, and he receives a blow in the side that tries his self-control; it strikes another obstacle, and the harness breaks; he must mend it with insufficient tools and materials; the horse becomes chafed under the collar, and he must find a cure; he plows up a bumble bee's nest, and narrowly averts a runaway; the whiffletree breaks, and with an ax and drawing knife he must make another to take its place." Emergencies such as these educate as nothing else can. They demand at the same time vigorous thinking and acting. They develop the self-reliant spirit most essential to success. At every point the country boy must make ingenious shifts without proper implements or supplies. He must think and act with promptness. He becomes resourceful and master of almost any situation or emergency.

It is a great aid to success for a young man to be early given serious responsibilities. An important part of the country boy's training for leadership is found in the constant demand upon him to bear part of the home responsibilities. At an early age he must be a factor in the earning power of the family. The systematic care of live stock, the work in field and garden, the hard economies and self-denials of a life of comparative poverty, produce habits of system, responsibility, and economy that tell for success in after life. The struggles with the soil, the exhilarating work of leveling the giants of the forest, the mastery and training of stubborn domestic animals, all cultivate superior will power and contribute to the ability to master and direct men.

"Nine trades out of ten," says William Drysdale, speaking of the superior advantages of the young country mechanic, "can be learned better in the country than in the large cities. In the country the establishments are smaller, there are fewer hands, and the apprentice gains a knowledge of all parts of the business. In the larger shops of the cities, with their hundreds of hands, the apprentice learns only one branch of the trade. In four years the country apprentice learns every branch. He is a complete mechanic." In the large city shops he

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learns only one department, and at the end is only half a mechanic.

"The chief elements of leadership," declares H. E. Kratz, superintendent of schools at Sioux City, Nebraska, "include strong will power, self-control, self-reliance, abundant energy, perseverance, self-confidence, courage, keen insight, quickness to meet emergencies, to act while thinking and to think while acting, and above all a firm belief in the power of man to shape adverse circumstances to his own purposes."

In such a school as the country a young man acquires the arts and aspirations of the leader. He is not only trained in early life to realize that he has a part in the world's work, that he has responsibilities which he cannot shift from his shoulders to those of others, but he is also trained to regard manual labor as worthy of respect, as elevating rather than debasing, and that the price of success is earnest effort.

The following statement by Dr. N. D. Hillis, of Plymouth Church, Brooklyn, showing the results of country training for leadership, should inspire every country boy and every man of country breeding to put forth the most earnest efforts to make his early, but not always recognized, advantages to tell for success in life: "A recent canvass of one of our large eastern cities showed that ninety-four per cent. of its leading citizens were brought up on the farm. An examination of one hundred commercial and professional representative men of Chicago showed that eighty-five per cent. were reared in the country or in rural villages. Seventeen of our twenty-three Presidents came from the farm. The brain and nerve centers of the body are not more dependent upon the soundness of the related tissues than the city is upon the rural districts. The leaders in the city are quickly succeeded by men from the country; they always have, and always will be."

The incomparable stimulus of rural life renders the senses keen and discriminating. Country life presents constant inducements to the fullest and freest exercise of the country boy's powers in shaping things to his purpose. He has the most favorable environment for the development of his mind, and especially of those mental and moral qualities that make for leadership and success. Add to these an education in the fundamental principles of engineering or business, such as is now within the reach of every country lad through correspondence courses of study, and his equipment to win success against great odds is far better than that of his city cousin.

Every man who possesses the mental and moral qualities and the bodily vigor that come from country boyhood, and especially those who have begun the effort to improve their condition through home study of technical subjects, should consider themselves fortunate in having so good a foundation upon which to build their futures, and should strive persistently to make the most of the natural advantages bestowed upon them by their early surroundings.

GOING STRAIGHT AHEAD

Be sure you are right, then go ahead; and be sure you are wrong, and then stop; but neither begin nor stop till you are sure. It is the frequent changing that defeats success. If you can never be sure, however, do not on that account fail to proceed, but go ahead on the best judgment you have and persevere with the same decision in doubtful matters as well as in clear; it is better to pursue wisely an unwise course than irresolutely to pursue a wise one. It takes time for success, and time in one direction. Changes are breaks in the line of prosperity, while one purpose followed through life will yield a rich harvest of something. Our tramps and nondescripts are men of many purposes, of which none were long pursued.

"Be sure," once said Hon. William E. Gladstone, "that every one of you has his place and vocation on this earth, and that it rests with himself to find it. Do not believe those who too lightly say 'Nothing succeeds like success.' Effort—honest, manful, humble effort—succeeds by its reflected action, especially in youth, better than success, which, indeed, too easily and too early gained, seldom serves, like winning the throw of the dice, but to blind and stupefy."

The world demands that everybody be a success in something. Men will honor a successful bootblack or a successful cobbler, but will show no mercy to a cobbling Senator or Congressman. If you are a failure in what you undertake, the world will turn a cold shoulder to you. Former United States Senator John Brooks Henderson, author of the Thirteenth Amendment to the Constitution of the United

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States, is an example of success through persistent effort. When a lad, he was bound out to a very penurious farmer in Virginia, where he drank poverty's cup to the very dregs. Out of his long working hours, during evenings and spare moments, he studied, after the farmer had retired, by the flickering firelight. He thus succeeded in getting education enough after awhile to teach a small country school, where he earned his first dollar. Here he studied Blackstone's and Kent's Commentaries, and laid, out of school hours, the foundations of an eminent legal career. Elected before he was of age to the State Legislature of Louisiana, he rose rapidly and was elected to Congress about the time Abraham Lincoln was defeated for the same honor. Elected, in 1860, as a Unionist to the State convention called in Missouri to determine the question of secession, he took active part as a Union man. Besides being author of the Thirteenth Amendment, he was one of the first in 1865 to propose an amendment granting suffrage without distinction, which finally took form as the Fifteenth Amendment. Removing, in 1870, to St. Louis, he engaged in the practice of law, which he has ever since pursued. He is now said to be worth three millions of dollars, and his magnificent home in St. Louis is far famed for hospitality.

One of the most remarkable examples of perseverance to be found in the range of human experience is furnished by the history of pottery. It was in the days when the now familiar glazing on chinaware was among the lost arts of antiquity, and coarse brown earthenware was universally in use. To the determined purpose of Bernard Palissy to discover this lost secret we owe one of the common necessities of today. His parents were poor—too poor to give him any education whatever. "I had no other books," said he, "than heaven and earth, which are open to all."

In the face of poverty, with the burden of a large family, he experimented for many successive years with various compounds, which, spread upon pieces of brown pottery, he endeavored to melt, to produce a white glaze. Failure succeeded failure, but though disappointed he decided each time to "begin afresh." In only one of his repeated experiments did the chemicals melt to produce a white enamel, and then on but one piece out of hundreds. He built his own furnace with his own hands, carrying the bricks from a neighboring brickyard; he was "bricklayer, laborer, and all." He made the last and most desperate experiment of all. The blazing fire, with intense heat, yet failed to melt the enamel, and the fuel ran short. The garden fence was torn down and thrown into the furnace. The enamel remained unmelted. The fire must be maintained at any cost. There were still the furniture and closet shelving. "A crashing noise was heard in the house," says Smiles, the biographer, "and amid the screams of his wife and children, who now feared that after his years of struggle Palissy's reason was giving way, the tables were seized, broken up, and heaved into the furnace. The enamel had not melted yet! Only the shelving remained. Another noise of wrenching of timber was heard within the house, and the shelves were torn down and hurled after the furniture into the fire. Wife and children then rushed from the house, and went frantically through the town, calling out that poor Palissy had gone mad, and was breaking up his very furniture for fire-wood!" But the last great burst of heat melted the chemicals and produced the first of the beautiful white enamel familiar today on even the cheapest ware. Even yet his object was not achieved. "Nevertheless," said he, "hope continued to inspire me, and I held on manfully; sometimes, when visitors called, I entertained them with pleasantry while I was really sad at heart." Persevering effort in the one direction finally won success; and today Palissy's ornamental pieces are classed among the rarest gems in valuable collections, and every one of us enjoys the benefits resulting from his efforts.

The man who desires to be successful must decide on some worthy object for his ambitions, and work for it through all circumstances. "Wealth," says Samuel H. Terry, Esq., "is rarely accumulated in any other way than by persistent and continuous effort in one direction; and then it may seem long to the anxious expectant before the reward comes. Spasmodic efforts to expedite it often do more to retard than hasten it, by betraying the attention from the sober and practical routine of details, an essential of success, and causing them to seem dull and plodding."

"It is not hard work," says President David Starr Jordan, "but work to a purpose that frees the soul. If the poor man lies down in

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the furrow and says: 'I won't try; I shall never amount to anything; I am too poor;' if he does this, I say, he won't amount to anything; and later in life he will be glad to spade the rich

RAILWAY WRITING SHELF
A Correspondence Student's Device

man's garden and shovel his coal for a dollar a day. But if he says to himself, 'I will be an engineer, an architect, a successful man;' if he never unsays it; if he bends all his powers in that direction, and takes advantage of all those aids that help toward his ends, and rejects all that do not, he will some time reach his goal. The world turns aside to let any man pass who knows whither he is going."

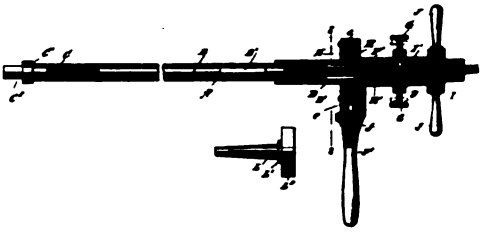
NECESSITY THE MOTHER OF INVENTION

The accompanying illustration represents a very neat little device known as the "Railway Writing Shelf." This shelf is of special interest to the class of people that spend a good deal of time in the railway coach or street car, especially to the suburbanite of a large city who spends from one to two hours a day on the train or street car, and for lack of something steady on which to hold his daily paper is apt to ruin his eyes reading its small print. The shelf makes it possible for a person to use a pen on board the car, with almost the same ease that he does at home at his desk. It is especially useful to students of The International Correspondence Schools, as it furnishes a good rest for the arm, and is so light and springy that the motion of the train or car scarcely interferes in the least with writing. One of the students of the Schools, Oliver A. Leonard, of 713 Masonic Temple, Chicago, Ill., is the inventor of the shelf, and uses it regularly twice a day in going to and from the city.

A brief description of the article may be of interest. It is made mostly of aluminum; its size when opened ready for use is thirteen by thirteen and a half inches, and when closed it measures six and a half by thirteen and a half, making it a convenient size to carry in the pocket, the weight of the shelf being but fourteen ounces. When in position for writing, the shelf rests on the car window sill, as shown in the illustration, and is supported by either a cane or umbrella, which is hooked to a brass clutch on the under side of the shelf, a small spring peg being slipped over the end of the umbrella or cane to keep the shelf from slipping. It is balanced and kept in position by two small brass hooks resting on the sill. Fixed in this manner, the shelf is strong, well balanced, and secure. It takes less than five seconds to take it down or put it up ready for use.

INVENTED BY AN I. C. S. STUDENT

Alfred G. Adelman, of Boise, Idaho, a student in the Schools, has turned his inventive genius to account in a patented choke-bore forming device. In making the patent-office drawings himself, he writes us that he used our Complete Drawing Outfit. The tool is intended to choke-bore shot guns by compressing the muzzles instead of removing metal from



the interior of the barrel. Mr. Adelman's device has the merits of not weakening the barrel and of enabling the operation of choke-boring to be easily and quickly performed.

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"KEEPING EVERLASTINGLY AT IT BRINGS SUCCESS"

CABINETMAKER BECOMES DRAFTSMAN

To any one desirous of advancement, and having neither the time nor money to secure a thorough college course, I recommend the Schools as the most practical method of instruction. The cost sinks into insignificance when compared with benefits received. The knowledge gained from my Complete Architectural Course has enabled me to substitute a pencil for a hammer. As draftsman I now receive $3.25 per day.—RUFUS L. RIEDEL, 318 Marais St., New Orleans, La.

PATTERNMAKER'S SALARY RAISED

I started at patternmaking with a common-school education, and found many problems which I knew nothing about. Noticing the advantages the students of your Schools had, I enrolled for the Complete Mechanical Course. After six months' study, I now hold a good position, am able to handle very difficult electric work with ease, and have had my wages increased. Every mechanic should take this Course.—E. ST. JOHN, 19 Oakland St., Lynn, Mass.

SURVEYOR AT THE AGE OF 19

I cannot endorse your Schools too highly. When I left the public schools, I took up the Civil Engineering Course in the Schools. I was soon offered a temporary job with a surveying party, earning $40.00 a month, and have lately been with another party, making $70.00 a month. I advise all young men who desire an education to avail themselves of the opportunity to enroll for a Course in the Schools.—A. E. FALKENBERG, 511 Friendship Lane, Waverly, Baltimore, Md.

WOOD TURNER BECOMES DRAFTSMAN

When I enrolled for the Complete Architectural Course, I was a wood turner, and knew little of drafting. The knowledge gained from my Course has enabled me to draw many plans for buildings, one being a $5,000 frame building. I have just completed the plans for a modern brick building, and intend superintending the erection of same. I wish to thank the Schools for the closeness with which my work was corrected. —I. L. TOBIAS, Assumption, Ill.

FARMER TO DEPUTY COUNTY SURVEYOR

I cannot express the gratitude I feel towards the Schools. While a farmer, with very little education, I took the Surveying and Mapping Course, and was soon afterward appointed deputy county surveyor at $5.00 a day. I am still "cruising" at $5.00 a day whenever the weather will permit. My advice to any one who desires to improve himself, and to rise in life, is to enroll at once. All I have gained I owe to the Schools.—THOS. H. ALLMAN, Cathlamet, Wash.

SALARY INCREASED 65 CENTS PER DAY

My knowledge of mathematics was limited, which made it difficult for me to estimate work of any kind in my trade as carpenter. Since taking the Complete Architectural Course I am able to make correct estimates and solve all problems. My salary has been increased 65 cents per day, in addition to which I am preparing plans and specifications for several buildings, thus increasing my salary still more.—H. P. FIKE, 30 Adams Ave., N. Peru, Ind.

FROM BLACKSMITH TO DRAFTSMAN

I have found the knowledge obtained from the Mechanical Drawing Course invaluable to me. With little effort, and the aid of the Schools, I have secured an education which has not only qualified me for a responsible position and better pay as machine blacksmith, but enabled me to illustrate my ideas in mechanical devices, and hold my position as draftsman with Stein & Boericke, metallurgical engineers.—GEO. PETORIN, 1518 Poplar St., Philadelphia, Pa.

BECOMES A MECHANICAL DRAFTSMAN

Being ambitious to learn more of mechanics and mathematics, and my time and means being limited, I enrolled for the Electrical Engineering Course. I was, at that time, instructor of machine work at the Sockanossett School for Boys, and came across many problems which I was unable to solve, but which, thanks to the Schools, I have mastered. I now hold a position as draftsman for the Universal Machine Co., of Providence.—BENJAMIN PICARD, Howard, R. I.

CLERK SECURES POSITION WITH ARCHITECT

One year ago, while employed as a clerk, I enrolled for the Architectural Drawing Course in the Schools. Three months later I secured a position in an architect's office, and am now drawing a good salary. I soon found that what I had learned made my work so plain that I could not afford to stop, so took up the Complete Architectural Course. No young man can afford to lose what the Schools can give him.—WELLS INGERSON, 2006 Midland Ave., Syracuse, N. Y.

NOW CHIEF ENGINEER GREENVILLE ICE CO.

When I enrolled for the Stationary Engineers' Course, I had had twenty years' experience in the construction and running of machinery. I am now employed as chief engineer of the Greenville Ice Co., and the instruction I have received has not only lightened my work, but has led to an increase of salary. My employers, impressed with the work I have done under your instruction, are going to advance me to a still better paying position.—WILLIAM KRAFFT, Greenville, Tex.

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THE INTERNATIONAL CORRESPONDENCE SCHOOLS, SCRANTON, PA.

JOHN VAN VORST BOORAEM

ONE OF GREATER NEW YORK'S MOST SUCCESSFUL ENGINEERS

Success is not often won through one steady upward climb. Few men reach the final goal of financial security without reverses that would take the heart out of many. "Life," says Robert Louis Stevenson, the famous author, "is not intended to minister to man's vanity." Every man who is struggling upward, must expect to be thrown down, perhaps many times in his life. We strive, and failure comes A fresh start must be made. But strength is gained by the striving, which fortifies us against many another threatened fall, of whose possibility we may not even be aware.

Mr. John Van Vorst Booraem, now one of Greater New York's most successful engineers, was born at Jersey City something over sixty years ago, in a well-known Dutch homestead situated on what were at that time the immediate banks of the Hudson, just opposite the city of New York. His education was begun in a school at Sing Sing, N. Y., and completed at the Polytechnic Institute at Carlsruhe, Baden, Germany. While alone for so many years abroad, he had utilized his vacations to visit different countries, had also made many walking trips with his fellow students, traversing thus Holstein, Switzerland, Italy, Tyrol, the Black Forest, and other regions; and visited and studied many manufacturing plants.

JOHN VAN VORST BOORAEM

The serious work of his career was to be done, and entering a machine shop, when nearly twenty-two years old, he donned the overalls as a helper, with wages at a dollar a day. The shop was in Brooklyn, and it was necessary to cross the Hudson, traverse New York City, and cross the East River before seven o'clock in the morning; then to return over the same route at the end of the day's work, to reach his home which was still in Jersey City. This made long days and cold work in winter, but he persevered and at the end of a year was promoted to the drawing department, thus shortening the service one hour. In a couple of years he was head draftsman, and was intrusted with the control of the work in several departments. The works also were being extended, large tools placed in machine and boiler shops, a large forge and foundry built, and a coppersmith shop and brass foundry added, in all of which he carried his share of the work and gained invaluable experience. Large government contracts were taken by the establishment, to build machinery for the new vessels of the navy. Machinery for double-enders, gunboats, and sloops of war were built and erected; he was required to look after the work, till the final test of acceptance was made.

Everything had been rushed during the war; but unfortunately changes in the condition of affairs, and a business depression, followed. The great amounts of money spent by the government on the war caused expenses and drains on business everywhere. Prices were enormous, money cheap, and the tariff made building too expensive and profits doubtful. Ship building ceased to be carried on in this country, and naturally no driving machinery was required. Few masts and sails were to be seen at the great docks of New York, nor have they ever come back so plentifully as they were in the early days.

In those times there was no work for marine engineers; they took what they could get, and were often seen peddling on the streets. All

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the old shops were weakened and lost large amounts of money during the war, owing to the failure of the government to keep its unit of value constant. When the government contracts were made, copper, for instance, was selling for eleven cents a pound, but the value of money became so reduced that before the same contracts were finished, sixty-four cents were paid for the same article. Owing to such losses of money and to the dull times, many shops closed. Mr. Booraem found it necessary to abandon marine engineering and turn his attention to other branches. He was fortunate enough at this slack time to get a chance to begin over again as draftsman.

A new sugar refinery was to be built. Under the supervision of the president of the company he prepared the plans and specifications for buildings and machinery, and erected the plant, this occupying a year. He was made superintendent of the refinery, and continued these duties until a second plant was to be built and a third acquired. After building and connecting these, he accepted control of their united mechanical departments, together with the responsibility of all designing and building.

This condition continued until early in the eighties, when some few of the stockholders, having built, near by, the largest refinery in the world, found trouble in getting it started. The main and controlling difficulty lay with the centrifugals. Owing to ignorance of the theory of this apparatus, they had been improperly mounted, and being of large size, neither manufacturer nor owner could run them without disabling them or damaging the building. Several of them had been badly bent, and as a result the whole plant, costing several millions, was at a standstill, while all were ignorant of the cause of the trouble. Finally Mr. Booraem, in charge of the neighboring plant, was consulted, and after an inspection agreed to have some of the machines ready for operation upon an early day. The trial was successful, and the refinery started. Mr. Booraem completed this refinery and accepted the charge of its mechanical department. This was no light task, as neither concern hesitated to spend large sums yearly in experiments, all designing and building falling to his share. Owing to the enormous size of this latter plant, and the generous policy of the owners in making improvements, it long stood as the model establishment of the world. Some idea of its size may be obtained from its daily consumption of fuel, which was six hundred tons.

After the formation of the American Sugar Refining Company, Mr. Booraem was asked to become the consulting engineer of the manufacturing committee. He held this position for nearly ten years, and met weekly with them until he resigned, two years ago. He is a prominent member of the American Society of Mechanical Engineers and of the American Chemical Society.

The following words of advice to men in the engineering trades and professions, coming from so prominent and experienced an engineer as Mr. Booraem, should have great weight: "Under the plea that 'forewarned is forearmed,' I would like to state a practical point or two, indicating where I have seen so many failures. I have no hesitation in saying that the greater number of failures among men, other things being equal, comes from the drinking habit. The social glass acquired in youth is the entering wedge by which Time drives the habit home with irresistible force. Many and many a time, when the employer wants help, he canvasses his men for preferment. The question is, 'How will Mr. Blank do? He seems bright and intelligent, and has the necessary education.' The answer is, 'O, but he drinks.' Now the man never knows that his opportunity has come and gone.

"A second point that men should take home to themselves is that an employer naturally chooses his aids from those who render him the greatest service, as they would do in his place.

"The man who works for his employer as he would work for *himself* in this advancing market, is sure of final success, providing he is honest. During working hours he must give his whole thought to the work before him. His own conscience will tell him if he is worthy of success.

"Then there is the bright smart fellow who is after a commission on goods handled for his employer. I imagine the second greater number of failures in life arises from this error. This man is not honestly seeking his employer's interest, and nothing can prevent his ultimate failure.

"To put it all in a nutshell, those who are willing to do for their employer only as others do, cannot expect success; for those that do all that they are able will be selected for advancement. It is the survival of the fittest."

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SUMMER STUDY

DO NOT GIVE UP STUDYING BECAUSE THE WEATHER IS WARM

Do not put off self-improvement until tomorrow, next week, or cooler weather. The habit of putting off things belongs to tropical lands. The motto of the tropics is "Manana"—tomorrow. We will do it tomorrow; today let us eat and sleep. "Manana, Manana," is heard at all suggestions involving the least exertion. It is too hot today, too much sunshine, too pleasant in the shade. "Manana," they say, "why should we do things, when to rest and not to do is so much pleasanter? There is the endless succession of tomorrows; tomorrows have come to us since eternity, and surely they will continue to come; let us rest in the shade and wait for the next tomorrow!"

Living in progressive America, do you want to belong to the land where nothing is ever done? To be classed with the nations and individuals whose progress is backward, not to the front? That is exactly your class, and the name of your country is "Manana," if you postpone, this summer, the opportunity to lift yourself a round higher up the ladder of success.

In the history of human endeavor and achievement, you will find no names of men who gave up before such trifling obstacles as a little summer heat. "Look at the great workers in the world," says James Freeman Clarke, "and see how they fought their way to triumph against all sorts of opposing obstacles. Milton wrote 'Paradise Lost' in blindness and poverty. Hugh Miller, who became one of the first geological writers of the century, was apprenticed to a stonemason, and while working in the quarry already began to study the stratum of red sandstone lying below one of red clay. While other men complain of circumstances, the man who has an idea and a purpose compels these untoward circumstances to serve him. James Watt, the inventor of the steam engine, was a poor sickly child, not strong enough to go to school. John Calvin, who gave a theology to the seventeenth and eighteenth centuries, was tortured with disease all his life. So was Robert Hall, the greatest preacher of his time. In what cradle of easy circumstances were Pascal and Shakespeare, George Fox, the Quaker, Spinoza, the famous Dutch philosopher, and Charlotte Bronte, the novelist, rocked into success? They were pillowed on hardship, taught by poverty, made strong by neglect, made pure by loneliness. When were circumstances ever favorable to any great or good attempt, except as they were compelled by a determined purpose to become favorable?"

No student who earnestly desires better things will let anything but serious illness interrupt his studies. Study in the hot months is neither fatiguing nor injurious to the health. It is a positive pleasure to the student who considers the prospect of future advancement. Every minute devoted to study brings him just that much nearer to the advancement which he seeks.

By hundreds of examples it is imperative upon us to make every moment tell for our advancement. If a genius like Gladstone always carried a book in his pocket, lest a precious spare moment escape, what should we of common abilities not resort to, to save of our time the odds and ends, to say nothing of periods of months? Roger Sherman, the famous judge and statesman of New Haven, had no educational advantages whatever, yet was so eager in the pursuit of knowledge that when apprenticed to a shoemaker he often had a book open before him while at work. Charles C. Frost, afterwards the famous naturalist, when apprenticed to the same trade, laid the foundation for his future fame on his resolution, strictly carried out, to read and study one hour each day. While other students were idling and chatting their time away, Joseph Cook, later the great preacher of London, would take up a dictionary or some other book, even if he had only a minute, and learn something of use.

"Avoid idleness," says Jeremy Taylor, "and fill up all the spaces of your time." Continuous effort conquers all things. The hard workers in responsible positions never clamor for the shortening of their hours, never depend upon their wits to make their way in the world, nor collapse because of a temperature of eighty degrees or more. They succeed, because, like Walter Raleigh, they "can toil terribly." They believe, with William Von Humbolt, that "work

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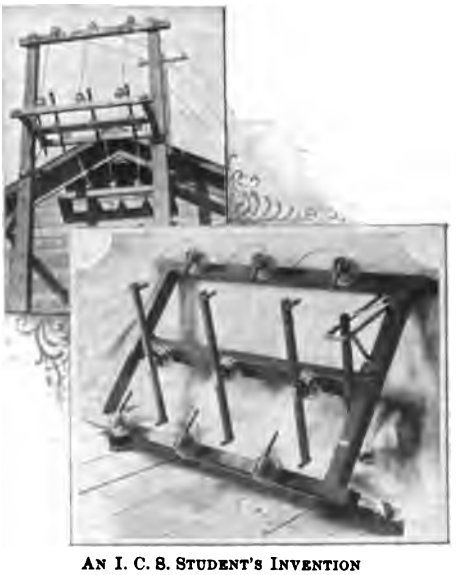
is as much of a necessity to a man as eating and drinking." They follow the example of Webster, who said, "I have worked on an average for more than twelve hours a day for fifty years." They accept the testimony of Walter Scott, "There is nothing worth having that can be had without work."

No man exists, even if sick, and crippled, on his bed, that cannot fill a place of some kind in the world, if he will but make the determined effort to surmount all obstacles and make full use of his time. Lives have blossomed into the greatest possibilities for themselves and for mankind, that have grown up through difficulties, and in darkness to which it seemed as if no light of education could have penetrated.

He who resolves upon any great end, by that very resolution has scaled the barriers to it. He who seizes the grand idea of self-cultivation, and solemnly resolves upon it, will find that idea, that resolution, burning like fire within him, and ever putting him upon his own improvement. Let him hold it ever before his face. Let it be his guiding star day and night, winter and summer, and he will find it removing difficulties, searching out or making means, giving courage for despondency, and strength for weakness.



AN I. C. S. STUDENT'S INVENTION

CARE IN WRITING

Written differs from spoken discourse in three respects. (1) It must be more exact than speech. A written word must express neither more nor less than the thought intended. (2) Written statements must often be guarded and qualified to be kept safely within the bounds of truth. (3) The writer should say only what he knows to be the exact truth, for he may, perchance, in the case of his statements being challenged, have opportunity of neither oral explanation nor correction.

HIGH-TENSION ELECTRICAL SWITCH

We illustrate herewith a very simple and effective high-tension switch invented by Mr. Frank F. Whorff, a student in the School of Electricity, and superintendent of the Power Development Co., at Bakersfield, Cal. High-tension switches are necessary in connection with the long-distance electric-transmission plants now being installed in so many places, and this switch is one which is very easily made and at the same time very effective. Between the clips of the switch is a copper fuse 28 inches in length, mounted in a tube so that the switch also serves as a high-tension fuse holder. The construction and action of the switch will be apparent from the figures, one of which shows the switch as it is mounted outside, and the other shows the switch open. All parts are mounted on high-tension glass insulators so that a degree of insulation fully equal to that of the line is secured. We are always pleased to receive descriptions of such electrical devices invented by our students, and believe the above will be of interest to all who have anything to do with high-tension transmission work. Students who have made inventions of any kind whatever are cordially invited to send photographs and description to the I. C. S. Department Editor of SCIENCE AND INDUSTRY.

The greatest philosopher of time, ancient or modern, Lord Francis Bacon, who had perhaps as much experience in the management of men as any one ever had, says this about it, "If you will work on any man, you must either know his nature or fashions, and so lead him; or his ends, and so persuade him; or his weaknesses and disadvantages, and so awe him; or those that have interested him, and so govern him."

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QUALITIES ESSENTIAL FOR LEADERSHIP

I.—Strong Will-Power

So large a proportion of the readers of Science and Industry are preparing themselves through technical education for opportunities as foremen and superintendents, and for other positions in which they will have to manage men, that we are beginning a series of short articles on the qualities essential to successful leadership. Not all understand clearly what qualities they ought to possess. Nothing is so helpful to one who desires to accomplish something as to know the precise conditions of his task. We take pleasure, therefore, in presenting the first of a series that will continue for some months to come.

Of prime importance in the achievement of success is education. But it is of equal importance for the ambitious man to cultivate certain necessary traits of character. Many, also, should restrain themselves in some respects, for too strong characteristics may be as detrimental as too weak.

Energy of will—self-originating force—is the soul of every great character. Where it is there is life; where it is not there is faintness, helplessness, and despondency. "The strong man and the waterfall," says the proverb, "channel their own path." The great and the good draw others after them; they lighten and lift up all who are within reach of their influence. Manhood overtops all titles, character all riches. "Character is success," because it is the foundation of success. There may be little culture, slender abilities, no property, no social position; yet if there be sterling excellence, its owner will command influence and secure respect.

The corner stone of character is strong will-power. No one ever won success without great will-power to "eternally hold him to it," in the face of opposing difficulties. Even great abilities without it are of little use, for they are not forced to leave their mark. A person of only medium talents, but of great strength of will, can, by keeping always at the one thing, win a great success. There never was a man distinguished for anything whatever without it. Will-power is absolutely indispensable to either greatness or goodness. Success in life depends on it more than on any other one quality.

To become a captain of industry, even in the humblest position of leadership, a man must possess a strong will. He must be able to bring all his forces to bear, that each may have its effect. Otherwise he will not leave his impress on those with whom he deals, both above and below. Without force of character he cannot retain the respect of his subordinates, nor give them the energizing inspiration that will cause them to apply their utmost abilities to their work. "A successful business organization," says Andrew Carnegie, "should be like a band of brothers"; and this cannot be attained without the affiliation that is born of respect for strong character.

A man not possessed of will-power lacks perseverance; the poorhouse is full of people who could not stick to one purpose. He is irresolute and fickle. He continually puts things off; he cannot realize with Dr. Henry Sabin, that "Yesterday is dead, tomorrow is unborn, today is the crisis of life." He drifts with the current, and may be easily persuaded, often against his best judgment. In extreme cases he is fitful and impulsive, like a feather driven here and there by every changing breeze. He becomes a perfect creature of circumstances, unable to accomplish anything calling for the least perseverance.

No man need even expect to succeed, who, when circumstances demand, cannot stand like a granite wall against opposition of all kinds. Men in positions of authority often meet the most intense opposition to even very necessary moves—opposition which, if not overthrown, or worn out by steadfast persistency, will produce certain ruin. A splendid example of strong will-power, wisely directed, is seen in Abraham Lincoln; slow to decide, when decision was reached he was firm as a rock; careful to count the cost, to weigh beforehand difficulties and opposition, all hesitation disappeared at the right moment, and he stood forth, the man of action.

One thing that will weaken the force of the will is too much deliberation. Some men are unable to decide because they see too many considerations, for and against. The man who

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sees but one—the most important one—quickly makes up his mind and goes ahead. Mr. P. T. Barnum used to illustrate this in one of his favorite stories, about two generals equally gifted and educated, but differing in the possession and lack of decision of character.

One hears the cry, "The enemy are coming, and they have got cannon."

"Got cannon?" says the hesitating general, who has not fully considered exactly what he would do under precisely these circumstances.

"Yes."

"Then halt, every man."

He wants time to reflect. His hesitation is his ruin; the enemy overwhelms him with a rush.

On the other hand, the general of decision, perseverance, and self-reliance, engages battle on the moment with whatever facilities are at hand; and amid the clash of arms, the booming of cannon, the shrieks of the wounded and the moans of the dying, you will see this man persevering, going on, cutting and slashing his way with unwavering determination, and inspiring his subordinates to deeds of fortitude, valor, and triumph.

A man of strong will-power holds on hard and long. He carries out what he begins. He begins wisely, because he will begin nothing that he cannot complete. Only the most potent reasons turn him from his path. Through all difficulties he drives determinedly straight ahead. He is prompt to decide, and holds on tenaciously through good report and evil. Overcoming all obstacles, shrinking from no difficulties, relying on his own judgment, and yielding to no persuasion, he presses on with eyes set ever on the mark.

The will-power of George Washington often snatched victory from defeat, and endowed his officers and men with added powers. It is related that Governor—then Colonel—Brooks received an order from Washington to go somewhere, when lying helpless from rheumatism. He replied that he was unable to go. Back came the answer, "Sir, you *must* go." What Washington ordered must be accomplished! The ascendency of that strong will enabled him to mount his horse and go and do the required work.

Success in a position of leadership comes only to him who can make his will-power felt by, and through, even his lowest subordinates. Whether it be in control of ten men or ten thousand, one determined master mind should, like the nerve energy of the body, supply electric energy and determination to every person that has submitted to its control.

Perhaps some reader will imagine that he is not possessed of the kind of will-power required for success. *Every one has it*—he himself has it, if he will let it out. Let any faint heart turn to the words of President Jordan, quoted on page VII of our last issue, and see the outcome of such weak-mindedness. He should cultivate courage, and other things will follow.

It is fortunate that no man need continue to suffer from deficient will-power, who will make an effort to strengthen what he has. "To cultivate the will," says O. S. Fowler, whose wise advice has brought success to thousands, "have more of a will of your own; make up your mind wisely, and then stand to your purpose; be sure you are right and then hold on; surmount difficulties, instead of turning aside to avoid them; resist the persuasion of others; begin nothing not worthy of finishing, and finish all you begin; consider the rewards of perseverance; give up nothing till it is completed; let no obstacles turn you from your purposed course; never allow yourself to be persuaded contrary to your better judgment; steadfastly resist temptation, and remember that those who hold out to the *end* alone are crowned; especially never yield in the least where *right* is concerned."

Permanent advancement comes only to those whose character and actions demonstrate that they steadfastly purpose to qualify themselves for serious responsibilities. He who will not improve himself should not expect to be intrusted with the improvement of his employer's valuable property or business. At the foundation of all improvement lies a strong will; and it is incumbent on aspirants for advancement in responsibility to strengthen and train that without which success is at best but transitory —strong will-power—*force* of character.

Misfortune is not always to be dreaded, especially if we have endeavored to live a life "free from blame." "The diamond of character," says Durivage, "is revealed by the concussion of misfortune, as the splendor of the precious jewel of the mine is developed by the blows of the lapidary."

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SUCCESS ACHIEVED AT TWENTY-THREE

HON. BURT D. CADY, THE YOUNGEST JUDGE IN THE UNITED STATES

"There is one principle to which every boy must attribute his success in life, and that is perseverance," writes Judge Cady, the most unique figure in Michigan politics—a police justice when but twenty-three years old. Burt D. Cady was admitted to the bar on his twenty-first birthday, and at the very next general election was nominated and elected police justice in Port Huron, Mich., a city with a population of 20,000. His majority was over 800, and he led his entire party ticket. Honors continued to fall upon him, for a few months later he was elected Circuit-Court Commissioner of St. Clair County, by a majority of over 2,000, again leading the entire party ticket. Still more recently he was elected secretary of the Republican State League, the most important factor in the Republican politics of the Wolverine State.

NEWSBOY TO JUDGE IN FIVE YEARS

The extraordinary series of triumphs achieved by Judge Cady demonstrates that success is at the call of every young man possessed of energy and concentration of purpose. The Judge began his battle with the world at the early age of nine. At that time he carried papers, and since then has easily provided for his own wants. Among his customers were some of the prominent lawyers of the city, who now plead before his bar. At ten, Burt became ambitious to become a lawyer too, and as soon as he had fixed his eye upon this goal he allowed nothing to divert his gaze from its attainment. Entering a law office at eighteen, he studied while other boys played; and on the very day he was twenty-one, successfully passed the examination which enabled him to write "Attorney at Law," after his name.

"My boyhood days," writes Judge Cady to the readers of SCIENCE AND INDUSTRY, "were spent in selling papers, commencing when nine years of age and continuing until I was eighteen, at the same time attending the public schools of this city. During the eighteenth year of my life, and while in the third year of the high school, I left school and gave up the paper business, to study law. I remained in a law office until my twenty-first birthday, when I was admitted to the bar."

"Without perseverance under difficulties, I could never have got even where I am. I found it necessary to pass my first year in a law office, doing the work of errand boy, janitor, and clerical help, finding what little time I could for study—all without any compensation whatever. Notwithstanding this, I did not call on any one for financial assistance. I lived that year in the interest of my studies, and gave up all pleasures, except the study of botany, for which I had a strong liking while attending school, and which I continued for several years after leaving the schoolroom. The second year I received one dollar, and the third year three. The young man who can live, even at home, within these means is not entitled to any particular credit, but he must have the element of perseverance in his make-up."

"I consider education," continues Judge Cady, "the foundation of success. Circumstances may not be such as to permit all young men to proceed as far in their studies as they desire, as was true in my case, but they can make up for it afterwards. My parents were of very limited means, with a large family, and we had to make

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all the personal sacrifice of pleasure, recreation, and society, that a young man of eighteen would care to."

"There is one drawback to the public educational methods: that in his years at school a young man is not expected to confine himself to his studies or the business which he may have outside of school, but also to become a more or less important factor in social circles. It is apt to cause him to place himself in a position where his parents have to contribute to his existence during his attendance at school; and when he is through—if he does not come of a well-to-do family—he has still to be financially assisted, or else at once receive work for a moneyed consideration. In the average young man this destroys the desire for a higher education. His position in society becomes paramount to education and his future. Many young men that I know of, are, for this very reason, now, at the age of twenty-five or six, working for eight, nine, or ten dollars a week, who should be entering upon the road to some profession, or holding a position of responsibility in a commercial enterprise."

"Every young man must become subject to habits, good or bad, and during his life will have the temptations of almost every bad habit thrust in his path. It is a good thing for him to encounter these temptations at an early age rather than after twenty-five. It is better that he have them while young and as he grows older have their folly demonstrated to him, rather than to wait till he has reached such an age that a bad habit is bound to destroy all the happiness and welfare both of himself and others. Habits are governed largely by will-power, and if a person decides that his will is not strong enough to stand against temptations, he should seek to avoid them. The best way to do this is to avoid bad associates, a thing that sometimes has to be done at a personal sacrifice."

Judge Cady is very fond of good reading, and for young men recommends especially the reading of the modern novel, of the better kind.

The people of Port Huron are exceedingly proud of Judge Cady, and regard him as a genius and a man of destiny. No public gathering of any kind is complete without him, and his speeches give such evidence of wit and humor, as well as of argumentative power, as to attract attention all over the state.

As a Judge he has achieved distinction by fair and impartial rulings, and by the wise application of mercy in unfortunate cases brought before him. It is no secret that his party intend to send him to Congress as soon as he is old enough. In Washington he will be one of the quaintest and brightest figures.

With such an example of success before their eyes, young men, whatever their occupations or aims in life, may well take courage and strive for the attainment of some goal as honorable as that which the honor and firmness of purpose displayed by Judge Cady, at so early an age, have enabled him to reach.

AIM HIGH IN EDUCATION

"This is a practical age, and we look askance at dreams and ideals," says President David Starr Jordan. "We ask now: 'What is the value of education? What is the value of Christianity? What is the value of love, of God, of morality, of truth, of beauty?'—as though all these things were for sale in our city markets, somewhat shop-worn and going at a sacrifice."

"My son," says Victor Cherbuliez, "my son, we ought to lay up a stock of absurd enthusiasms, or else we shall reach the end of our journey with an empty heart; for we lose a great many of them by the way."

It is the noblest mission of education to fill the mind with these enthusiasms, with noble ideas of manhood, of work, of life. It should teach one to feel that life is indeed worth living; and no one who leads a worthy life has ever for a moment doubted this. It should help one to shape his own ambitions as to how a life may be made worthy. It should help one to believe that love, and friendship, and faith, and devotion are things that really exist, and are embodied in men and women. One should form plans of his own work for society, for science, for art, for religion. One's life may fall far short of what he would make it; but a high ideal must precede any worthy achievement.

GO SLOWLY

"Adopt the pace of Nature," says Emerson, "her secret is patience." "Everything comes if a man will only wait," is a saying of Lord Beaconsfield, England's great Prime Minister. "Imitate time," wrote the French essayist, Joubert. "It destroys slowly; it undermines, wears, loosens, separates; it does not uproot."

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SELF-CONTROL

A Quality Essential for Successful Leadership

The wisdom of all philosophers points to the absolute necessity of control of self in those who are to control others. "Keep cool," says Emerson, "and you command everybody." "The man who is to govern others," says Thompson, "should himself first learn to bend his own passions to the sway of reason." "It is the man that is cool and collected," remarks Diderot, the French philosopher, "that is master of his countenance, his voice, his actions, his gestures, of every part, who can work upon others at his pleasure." "Power," said Antonie St. Just, at a session of the Committee of Safety, during the French Revolution, to Robespierre, his friend, when the latter gave way to passion, "power belongs to the self-possessed." "No one who cannot master himself," says Goethe, poet and philosopher, "is worthy to rule, and only he *can* rule."

The great leaders of men have been characterized by remarkable self-control. The peculiarity and strength of Washington's character and the key to his success was great self-possession and calmness that enabled him to judge and to act with foresight and confidence impossible to men of equally forcible gifts but less self-disciplined. Gilbert Stuart, who painted his portrait, stated that Washington had a tremendous temper, but kept it under wonderful control, a statement to which the latter assented when informed of the remark.

Scott, the novelist, says of Napoleon Bonaparte, that he could dismiss from his face all expression except a vague, indefinite smile, making his features assume the fixedness and rigidity of a marble bust.

In early life Abraham Lincoln was exceedingly quick-tempered and combative. He learned self-control later, and became one of the most patient of men. He said of this trait: "I learned during the Black Hawk War the necessity of controlling my temper, and that good habit has stuck by me ever since." It was one of the chief elements that made possible his wonderful control of others.

General Grant was equally calm, self-reliant, and unperturbed, either at the sight of regiments breaking in defeat, or before the hero-worship of a nation, on the return of his victorious army into Washington in the Grand Review of the Army of the Republic.

The want of proper discipline over one's words and actions is a fruitful cause of failure, a constant handicap in the race for preferment, and has always been so recognized. "For want of self-restraint," remarks Samuel Smiles, "many men are engaged all their lives in fighting with difficulties of their own making, and rendering success impossible by their own outbreaks; while others, it may be, much less gifted, make their way by simple patience, equanimity, and self-control." Locke, the profound English thinker, tells us that the man that has not the mastery over his own inclinations; that knows not how to resist the importunity of present pleasure or pain for the sake of what reason tells him is fit to be done, wants the true principle of virtue, and is in danger of never being good for anything.

An example of the disastrous results of uncontrolled passion is fresh in mind. A few years ago, a gentleman of no little culture and the highest mechanical and executive ability, accepted the management of a well-known manufactory employing hundreds of men and presenting an unequaled opportunity for prominence in mechanical lines. The new manager produced work of first quality, and secured a satisfactory amount of business. But he could not get the best out of his men. There were frequent petty strikes and universal individual dissatisfaction among them, because of his unbearable profanity toward his subordinates, from lowest to highest. The directors were soon compelled to ask for his resignation. His failure was due entirely to lack of self-control.

In another large concern, where many young men are employed, it is noticeable that those that are promoted and go to the most responsible positions are the ones that control themselves under all circumstances. One man who rose in a short time from common labor to the managership of a large department, was given his important position, as stated by the super-

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intendent, solely because "he never became rattled."

For a man in a position of responsibility to express his thoughts and feelings spontaneously and instantly would be suicidal, both for himself and the business interests of his employers. His intentions, thus made known, would constitute a perfect guide for business competitors. He must frequently be noncommittal, and employ strategems to cover up his motives. Direct questions must often be evaded and ideas expressed guardedly. Important business plans must be carefully covered up and not divulged, even to intimate friends. A man is fortunate who, like President Arthur A. McKain, as stated in the next article, learns early in life the important lesson of silence as to intentions. Commodore Vanderbilt, the founder of the Vanderbilt fortune, considered it a vital element of successful management to tell no one what he intended to do until it was actually done.

A superior who is reserved and non-communicative beyond his immediate purposes, enjoys all the greater respect from his subordinates. To have the confidence of such a man is generally considered a mark of high esteem. Men who wish to succeed should not pursue too open and direct a course. Their looks and actions must not betray what is passing in the mind. Policy must be employed, not to deceive others, but to protect themselves and the business interests confided to their care against the attacks of ambitious and unscrupulous rivals.

Those who command themselves command others. It is capital to a man's credit to be able to control himself and all his faculties. Character is always capital, and one chief element of a strong character is self-control.

ALWAYS FAITHFUL TO EMPLOYERS

A Poor Boy's Rapid Rise to Prominence

It has been the fortune of but few men to make as profound an impression upon any branch of the machine world as Arthur A. McKain, president of the Indiana Manufacturing Company, of Indianapolis, Ind., has made on the manufacture of agricultural machinery.

Born and reared in the most unfavorable environment possible, he encountered all the hardships surrounding a poor boy's life, and within a comparatively short time forced himself to the front. From an absolutely penniless lad, he has risen to be the head of a manufacturing establishment valued at half a million dollars.

In response to a request to Mr. McKain to relate some of his experiences in his struggle for advancement, for the benefit of the readers of Science and Industry, he has sent the following sketch of a life of early disadvantages and subsequent success. No reader who may now be laboring under adverse circumstances can but receive an inspiration from the example presented of perseverance under difficulties.

"I was born," says Mr. McKain, "on a farm in Miami County, Ohio. My father was well-to-do, and a farmer all his life. My mother was born in Albany, N. Y., and brought up in Cincinnati. They married after each had reared a family, the fruit of earlier marriages. I was, therefore, surrounded by a large family of half-brothers and half-sisters on both sides. The difficulties of such an arrangement were too much for my parents, and they separated when I was but ten years old. I went with my mother, and consequently suffered the inconveniences of poverty; at the same time I enjoyed the advantages of an early struggle under adverse conditions.

"I was obliged to go to work on a farm when I was a little more than 12 years old. My youth was against me, and I received many discouraging refusals in my quest for employment. One evening, after a vain search extending over many weeks, I was told that a boy had quit working that day for a farmer some three miles in the country. There was a group of boys near, and one of them said he would go in the morning and get the place. I went that night and secured the job at once. It was a lesson to me in promptness and in silence as to my intentions, by which I have profited throughout my life.

"The next incident which impressed itself most clearly on my memory occurred four

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years later, when I was working on a brick yard as off-bearer. We were paid seventy-five cents a day, the other hands receiving a dollar. My companion off-bearer said that we were doing harder work than the others, and getting less pay, and suggested that we slack up. Our employer came out, and noticing our dilatoriness, asked what was the matter. My fellow-worker, being older than I, made the explanation that we were not getting as much as the others, while our work was harder. Our employer at once said that 'we were taking a —— poor way to get any more.' I saw the force of his remark; but my companion did not, and he was discharged that evening. I stayed on until the yard was shut down in the fall. Ever since, when times get hard and discouraging circumstances suggest the letting up of effort, the remark of the old brick-yard man has always been a stimulant, and has helped me over many rough places."

In comparison with the educational advantages of many readers of this magazine, those enjoyed by Mr. McKain were very meagre, and render his success the more brilliant, viewed in these days of first-class public schools, and the educational aid at command in the great correspondence schools, and the colleges and technical schools. "I never obtained any education," continues he, "except what could be acquired before I was sixteen years old by going to school in the winter in our village schools, with the exception of one short term of three months in an academy. I loved to go to school, and never missed a day, except when I had to work; and"—what follows is doubtless one of the reasons for his success—"I never refused a day's work in my life. Such education as I have, I have acquired by reading and observation.

"I tried in all the machine shops and in every industry in Richmond, Indiana, and in Dayton, Ohio, to get a chance to learn a trade. This was when I was about fifteen or sixteen years old; but the other workmen and lack of influence kept me out, so that I have neither education of the schools nor of the shops. I was driven into commercial pursuits, and my early experience on farms gave me a bent toward supplying the wants of the farmers. I suppose it was this that influenced me to take up the manufacture of farming implements."

No words of advice are more valuable than those relating the causes of the success of thoughtful and successful men, by considering which we can often perceive more clearly what qualities to cultivate and rules of action to follow ourselves, to insure our own success. Speaking on this subject, Mr. McKain says, in closing: "I know of no particular reasons for my success, except that I was always faithful to my employers. I did all that I could for them, and did it as well as I could, and always tried to learn how to do it better. I never refused a task because it was difficult or disagreeable. I suppose it was these qualities that gained me the confidence and esteem of my employers. As a man I have been able to go back to them whenever I needed advice or financial assistance, and have always been able to obtain it. My employers were always my friends, and to this day, my very firmest friends are the men who employed me in my youth."

GLADSTONE ON SUCCESS

What Mr. Gladstone has to say about success in life is worth reading and worth thinking about:

"Be sure that every one of you has his place and vocation on this earth, and that it rests with himself to find it.

"Do not believe those who too lightly say effort—honest, manful, humble effort—does not succeed by its reflected action, especially in youth, better than success, which, indeed, too easily and too early gained, not seldom serves, like winning the first throw of the dice, to blind and stupefy.

"Get knowledge all you can.

"Be thorough in all you do, and remember that, though ignorance often may be innocence, pretension is always despicable. You must, like men, be strong and exercise your strength."

"Wondrous is the strength of cheerfulness," says Thomas Carlyle, "altogether past calculation its powers of endurance."

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PERSISTENCE IN STUDY

In self-culture, everything depends on the good use of time. It is not a great quantity of time that is needed, but the power of using all the time available.

You cannot, for instance, hope to accomplish very much, if you study today for an hour or two, and quit the next few days, because the weather is a little warmer. You cannot make much advancement, if you study in the cool months only. Time, it is said, works wonders, but time works twenty-four hours a day, and three hundred and sixty-five days in a year. If you sincerely wish to succeed, you must possess, in some degree, time's persistence.

All successful men are agreed on the importance of the thorough use of time. "I wish," says President Jordan, "to teach a single lesson, true alike to all men—the lesson of saving time. To students I say, 'The pathway of your lives lies constantly along the borders of the Land of Manana—the land of putting things off. It is easy to turn into this land and to lose yourself among its palms and bananas. To come to the full measure of your powers constitutes success in life. This depends on the factor of time. With time enough, we could, any of us, do anything. Any man could be all men, could he have time enough. With eternity, man becomes as the gods. But our time on earth is not eternity. We can do but little at the most. Every hour we waste carries away its life, as the drops of falling water carry away the rock. Every lost day takes away its cubit from our stature. Let us work while it is day; and when the evening comes, we may rest under the shade of the palm trees. He, only, that has been active in the heat of the day, has earned the right to sleep.'"

"He that stays does the business." The giants of the race have been men, not so much of extraordinary ability, as of tremendous concentration, who have struck with sledge-hammer blows, continually in one place, until they have accomplished their purpose.

Benjamin Franklin said that diligence is the mother of good luck. No man should complain of ill luck whose mishaps are more justly attributable to lack of diligence.

Let no reader of SCIENCE AND INDUSTRY who desires to carve out his fortune with the tools of training and education, neglect the golden opportunity of the next two warm months to place himself two months ahead of others who may suspend their efforts till cooler weather.

DESIGNED BY AN I. C. S. STUDENT

A STUDENT'S BUILDINGS

The two buildings illustrated on this page are the work of Mr. L. D. Brackney, of McMinnville, Tenn., a student in the Complete Architectural Course of the Schools. "They are," writes Mr. Brackney, "of the best class of buildings that have been built here in the last two years. I am aware that all of the proportions are not quite right, but think there are no serious mistakes. At least, as far as I know, my work has given perfect satisfaction to the owners. The Schools have been of great assistance to me. I had worked at carpentry several years, and studied considerably before enrolling, but have since learned much faster and been enabled to make much neater drawings."

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A JUDGE'S ADVICE

By Hon. Edward Ambler Armstrong, Judge of the Camden County Courts, Camden, New Jersey

It may be briefly said to the men whom Science and Industry reaches, that they cannot know too much, although in a limited way it may be true that "A little learning is a dangerous thing." No learning is a great deal more dangerous, and it is far better for one to have a little learning than none at all. The criticism, of course, embodied in the oft-quoted phrase above mentioned, is that the one with little learning feels assured that he knows it all.

It happens, I suppose as a general thing, that a man feels that because he cannot attend a technical school, he cannot obtain a technical education. This, of course, is not at all true. While the work for a technical education will be harder, it can be obtained independently of schools, and is bound to be a great and controlling factor in any man's success.

Doing the work assigned, faithfulness to the employer's interests, and absolute trustworthiness are sure to win not only the confidence but the regard of an employer. No man is important enough to fill a place that no one else can fill; but a man can make himself so useful and so important that an employer would fill his place regretfully.

Generally speaking, any man can be successful, if he will. More than this world dreams of rests in that spark of divinity in every human breast, *the will*. Any man can make money in this country, and if that is his entire object in life—to become rich—the attainment of his object would depend on whether he saves or not. Being rich is entirely relative: a man whose income is two hundred and fifty dollars and whose expenses never exceed two hundred dollars a year, is rich; while a man whose income is twenty thousand dollars a year, and his expenses twenty-one thousand, is miserably poor.

If I were to sum up, in a line, a rule for both happiness and success, I think it would be by saying: "Act well your part, for there the honor lies."

"YOU MUST NOT FORGET"

A successful business man said that there were two things which he learned when he was eighteen, and which were ever afterwards of great use to him, namely: "Never to lose anything and never forget anything."

An old lawyer sent the young man with an important paper, giving him definite instructions what to do with it.

"But," inquired the young man, "suppose I should happen to lose it, what shall I do then?"

"You must not lose it," said the lawyer.

"I don't mean to," said the young man, "but suppose I should happen to?"

"But I say you must not happen to. I shall make no provision for such an occurrence."

This put a new train of thought into the young man's mind, and he found that if he was determined to do a thing he could do it. He made such a provision against every contingency that he never lost anything.

He found this equally true about forgetting. If a certain matter of importance was to be remembered, he pinned it down in his mind, and made it stay. He used to declare: "When a man tells me that he forgot to do something, I tell him he might as well have said, 'I did not care enough about your business to take the trouble to think of it again.'

"I once had an intelligent young man in my employ who deemed it sufficient excuse for neglect of a task to say, 'I forgot.' I told him that would not answer; if he was sufficiently interested he would be careful to remember. It was because he did not care enough that he forgot. I drilled him with this truth.

"He worked for me three years, and during the last year of the three he was utterly changed in this respect. He did not forget a thing. His forgetting, he found, had been a lazy and careless habit of mind, and he cured it."

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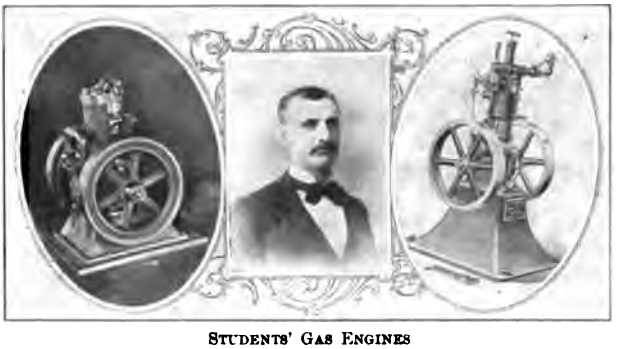
AN I. C. S. STUDENT'S OPPORTUNITY

Words of greater truth were never spoken than when President David Starr Jordan said: "Only in our day has it been recognized that the common man had part or lot in higher education. Now he has come into his own, and demands that he, too, may be noble and gentle." President Jordan may not have realized it, possibly, but it is through correspondence schools that the man who has to do the laborious work of the world is winning his place among those who know, and can, therefore, do.

The following story about an I. C. S. student shows that the man in overalls, soiled and grimy, can often make his knowledge felt by those whose lot in educational matters has been more fortunate: Mr. Worthington, who is a graduate of a well-known technical school, and occupying one of the head positions in the electric railway system of a large western city, was recently called into his chief's office and handed some calculations involving a knowledge of cube root. This was an easy task; he set to work, but in a very short time found himself completely at a standstill. Not wishing to admit his inability to his superior, he approached another technical graduate employed in the works. The latter essayed the task, but did no better than Worthington.



STUDENTS' GAS ENGINES

While they were standing in the engine room, puzzling over the difficulty, the fireman, who was wiping oil from the engine, asked what the trouble was, and created no little merriment by offering to help. With a piece of chalk, however, he set to work on the wall of the room, and soon produced the correct answer.

Worthington and his friend were greatly surprised to find an engine wiper giving them points on mathematics; but the explanation was that the fireman was a student in the Schools, and proudly claimed that, although not long before he had been almost totally ignorant of mathematics, now, not only could nothing in arithmetic puzzle him, but he was mastering physics, the theory of the steam engine, and the principles of dynamo-electric machinery, and would soon be qualified for a position as chief engineer.

GAS ENGINE DESIGN

One of the newest and most attractive fields for inventive minds is the design of gas engines. Comparatively little is understood, generally, about the principles of the gas engine, and those who study this modern kind of engine are often able to make great improvements.

The two gas engines illustrated herewith are the inventions of two students in the Gas Engines Course of the Schools. The student whose picture is given is Mr. Charles F. Martin, of Clinton, Mass. His engine is the one at the right. Mr. Martin says that his Course more than met his expectations, and that through its aid he will be able to keep in the front rank of the makers of gas engines.

We regret that we have no photograph of Mr. George Kingston, of Ionia, Mich., the designer of the engine at the left. "I have been putting my education to some practical use," writes Mr. Kingston. "I have designed and built a gas engine, a photograph of which I send you. I now have under construction a double-cylinder motor intended for automobile work. It has $3\frac{3}{8}'' \times 3\frac{1}{2}''$ cylinders, with continuous water-jacket around both cylinders, and is of the two-cycle type, although different from anything on the market. I have done all the work myself, even the core making, molding, pattern work, and machine work. When I began the Course I was a carpenter and knew nothing about metal working."

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NEVER LIMIT YOUR EFFORTS

The road to success is as clearly mapped out as the best highway to a large city. Success is as certain of attainment by the man who fulfils the conditions of success, as failure by him who fulfils the conditions of failure.

The way to either is not hard to find. It may easily be ascertained through study of the experience of others, as embodied in innumerable books and articles of advice and biography.

Of especial value are the words of living successful men. Mr. R. S. Buck, C. E., who has recently been appointed to the important position of chief engineer in charge of the new bridge over the East River, at New York, has the following to say to the readers of SCIENCE AND INDUSTRY, on what his observation and experience have shown to be essential to success:

"Such success as I have attained is due to good fortune, good friends, a keen lookout for opportunities, and an inherent desire always to do the best that could be done, in small matters as well as large.

"One point I would suggest to all, no matter what their grade, and that is to abstain from the fear of doing too much work. The man who is constantly figuring how he can reduce his efforts to a minimum, without incurring censure or worse, is doomed to certain failure. Even more, the man who is always weighing the wear and tear on his mental and physical constitution, and *measures* his efforts, even though possessed of fair ability, will always be at the rear of the race. It may not be a good thing always to be keyed up to the concert pitch of effort, but in nine cases out of ten it is essential to success."

"COME HOME SOMEBODY"

Education, in its true sense, means more than spelling and writing—it means growth of power, the development of character. To turn out good, honest, and right-thinking men and women should be one of its principal aims. In this age of personal vanity and love for the almighty dollar, there is an imperative need of the most vital moral training possible, and it is of utmost importance to us to pay closer attention to "character building." This is among the sore needs of the world.

> Dig, dig the foundation deep, young man,
> Plant firmly the outer wall;
> Let the props be strong and the roof be high.

"Society," writes J. G. Holland, "not only demands that a young man be somebody, but that he shall prove his right to the title; and it has a right to demand this. Society will not take this matter up on trust, at least not for a long time, for it has been cheated too frequently. Society is not very particular what a man does, so that it proves him to be a man; then it will bow to him and make room for him."

"Try to come home somebody," said Gambetta's fond mother as she sent her gifted but poverty-striken boy to Paris to school. His food was, for a time, scanty, his clothing shabby, and his home a little room in a garret. But he had determined to succeed, and such obstacles as these could not restrain him.

An opportunity came. Jules Favre was, on a certain day, to plead a great cause, but on being suddenly taken ill, chose an unknown, rough, and uncouth young man to take his place. That young man was Gambetta, who for many years had been preparing for such an opportunity, and now proved equal to its demands. He made one of the most powerful speeches that had, up to that time, ever been made in France. All the papers of the French metropolis sounded the praises of the ragged, uncouth, Bohemian advocate, who soon became the Republican leader of all France. Not to luck or accident was this sudden rise due. The opportunity came and he was equal to it.

"John Wanamaker," says Manley M. Gillam, "delivered his first order in a wheelbarrow. He had just started Oak Hall, his father and himself having together barely $4,000 capital. There was rent to pay in advance, goods to buy, help to hire, and improvements to make. The

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$4,000 was put to the very best practical uses. The first order came and every attention was given to fill it as well as possible. The head of the firm, John Wanamaker himself, placing the big bundle in a wheelbarrow, wheeled it to the customer."

No grander sight in the world is there than that of a man filled with one great purpose, dominated by one undeviating aim. Bound to win, the world stands one side and lets him pass; it always makes way for the man with a will in him.

"WORK, WORK, WORK"

A man who long since reached the pinnacle of ambition as a subordinate, the Hon. Chauncey M. Depew, who has, it is said, the demonstrated ability to do more work at sixty than any three men around him, speaks of his own success as follows: "My experience as an employer of 35,000 men, and in contact with institutions which employ 100,000 more, is that most men fail in life from their own fault in not seizing the opportunities which come to them.

"What I mean is just this: I was in a large law office down town recently, and I said to the head of it, 'You are working yourself to death.' The head of every concern in this country is working himself to death because he cannot get the proper assistance. He said, 'Yes; and for this reason: look at that office full of clerks, every one of them watching me to see when I am out, so that they can fool away their time, and every one of them watching the clock to see when the time comes for them to leave. If there was among that body of young lawyers out there, and of clerks studying to be lawyers, any one who was willing to take up any work that I would send out there, and stay here all the afternoon and all the evening, and all the night, if need be, as I did when I began, that man in a few years would be my partner; but there is not one, not one.'

"It is the rarest thing in the world to find a man who is taking wages or taking a salary who is willing to do any more than he knows he is hired to do. When you ask him to do anything outside of that, he wants to know if you are going to raise his wages or give him extra pay for it.

"You take any large counting house; you take any large factory; you take any large employment anywhere, and you will find that ninety-nine out of every hundred, if the hour for quitting is five o'clock, at half-past four have their eyes glued on the hands of the clock. If you find among them one man who, when one of his fellows is sick says, 'Very well, I will do your work,' or when the work of the office has fallen behind, goes to the head of the office, and says 'All right, I will stay here until that is finished up,' that man is certain to walk ahead and climb the ladder, if he keeps his health and stays where he is.

"If any one should ask me what is the secret of success in life, I should say, 'Work, Work, Work.'"

TRAINING REQUISITE TO SUCCESS

Unless a man possesses exceptional ability, says the *New York Tribune*, or fits himself to do something exceptionally well, there is no place for him today in the world of business. The one fatal qualification for a business career is mediocrity, even though it is crowned with the virtue of faithfulness. The man whose only stock in trade is the ability to do routine work faithfully, as a thousand other competing young men can do it, might almost as well go to the poorhouse at once, for he is on the straight road to it. As an unskilled laborer, there is no possible chance for him in the modern business world, unless he is content to plod along all his life from hand to mouth, as some other man's man. The world is overstocked with men who can do routine work well, but not supremely well. And it is crying aloud for men who by patient learning have qualified themselves to join the ranks of the select few who can do some one thing better than anybody else.

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HONESTY, PERSEVERANCE, AND CONCENTRATION SUCCEED

By James Oliver, the Millionaire Plow Maker

A man may acquire a goodly share of the world's goods by dishonest methods, trickery, and deceit, but his success will be short-lived, unstable, and unsatisfactory. No man base in deed is at rest in mind, and if money will not bring mental as well as bodily comfort, of what good is it? Worst of all, a dishonest career must some day close, and the mere thought of the ultimate reckoning will undo all the pleasure that ill-gotten gain may have given.

A man should be scrupulously honest and honorable in all his actions. Never should he sacrifice conscience to gain wealth, or foster the belief that success is simply the accumulation of money. Then he must persevere. He cannot gain worldly success without an invincible determination to succeed, and ability, talents, and circumstances will count for little without tenacity of purpose—stubborn perseverance to get to the front. Upon no one but himself should he rely. He is the best friend he has on earth, and nothing will in after life be more hurtful to him than to look outside himself for support while his character is shaping itself. It weakens his character and curtails the scope of his intellect.

Further, a man to be successful in business must apply himself unswervingly to his work. His whole mind and heart should go deep into it, and he should cultivate a growing fondness for it. Unsteadiness or fickleness can never be made to harmonize with success.

No matter how insignificant may be a man's first situation, he will find that there is much to learn from it, and he should be always keenly observing. Accuracy, too, should be one of his characteristic qualities. His work should never necessitate a second "going over" by some one else. Then, he should learn to do his work systematically. The smallest business requires system. He should study carefully some method by which he can economize time, and then live up to it. At his work he should always be on time. Punctuality is a virtue that employers perhaps recognize as quickly, if not more so, as any other. If an employer sees an employe always behind time in coming to work while engaged under his very nose, he is apt to conclude that if that employe were placed wholly upon his own responsibility, he would be even more reckless, and in consequence the employer appoints a more regular man to the responsible position, and the laggard wonders why there has been any discrimination against him.

The successful man should do his work quickly, yet accurately, and should have the greatest regard for time. Persistent effort on the part of any man will be the means of cultivating such habits as are necessary in the successful performance of business.

I have every faith in the possibilities of the poor boy, and it is needless for me to cite any examples substantiating my belief. There isn't a boy in the land who cannot himself number offhand scores of men who have risen from the lowest ranks of poverty to the highest stations of eminence. The world's greatest artists, inventors, poets, and philosophers have forced their way to fame over the most stubborn rocks of adversity. The educational advantages that the poor boy may lack may in a way handicap him in the race of life, and he may have to solve his mathematical problems by longer methods than algebraic, but if he possesses those essential qualities to success—honesty, perseverance, and good common sense—he is bound to succeed.

I believe that poverty is a great aid in the development of success. We all know that too many advantages at the threshold of life's journey are a misfortune, because they dampen ambition, and a young man without ambition can never hope to succeed. The poor boy must resolve at the outset to encounter all the hardships of life unflinchingly, and, above all, to be patient. In that I do not mean to be effortless, to sit idly by waiting for success to come around to the door like the postman, but I would say that never should he be discouraged in his work."

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ONLY FIFTEEN YEARS AGO

It is not necessary to look back many years to find men whose names are household words today, and who have achieved both fame and fortune, occupying obscure positions and giving no indication of the brilliant future that was awaiting them.

Fifteen years ago Dr. Conan Doyle was industriously working up a medical practice, with all the attendant hard work and struggle, at Southsea. His pen was yet untried, and he seemed destined to live and die a country doctor. It was four years later when he was tempted to try his prentice hand at writing, with what results the world and his bankers know.

When Conan Doyle was dispensing physic at Southsea, Mr. S. R Crockett could not even claim the doubtful position of "A Stickit Minister," for it was only in 1886 that he entered the Free Church of Scotland, in which he served an apprenticeship of seven long years before he found that his vocation lay with the pen rather than in the pulpit.

At this time, too, only fifteen years ago, "Ian Maclaren" had won popularity as minister of Sefton Park Church, Liverpool; but for a dozen more years his pen was engaged in writing sermons before it turned to the pathos and beauty of "Beside the Bonnie Brier Bush."

Hall Caine, who can now rely on making his own weight in gold out of a single novel, was quite unknown fifteen years ago. After years of ill-paid journalism in Liverpool, he had come to London to be Dante Rossetti's private secretary, and to find scope and inspiration for the gifts that were in him. The change of environment worked a miracle; for, in 1885, his powerful "Shadow of a Crime" introduced a new "prophet" to the world of readers.

Fifteen years ago Anthony Hope was a scholar of Baliol, and his only ambition was to follow in the footsteps of his uncle, Sir Henry Hawkins, as he then was. It was not until 1890 that he proved himself "a man of mark" in quite another field of labor.

In 1884, Stanley Weyman, the gifted author of so many historical novels, was waiting for briefs in Dr. Johnson's buildings, and did not even attempt to solace his waiting hours by "trying his hand" at fiction, of which he is now such a master.

Rudyard Kipling, in the early eighties, was assistant editor of the *Indian Pioneer* on many less rupees a month than he now earns pounds a week. He was writing his "Departmental Ditties" in his few spare moments, and hoped some day, as the height of his ambition, to induce the world to read them in book form. Rider Haggard had already written one book, "Cetywayo and His White Neighbors," and published it at a loss of 50 pounds; and was on the verge of publishing "Dawn" at a net profit of 10 pounds for a year's hard work.

The same story may be told of scores of men now world-famous in other fields of effort.

The present Viceroy of India was reading for his B. A. degree at Oxford, in 1884, and was already looking forward to an apprenticeship to politics, which began in the following year as assistant private secretary to Lord Salisbury; Sir Alfred Milner was a hard-worked sub-editor of the *Pall Mall Gazette*, with never a dream of the days when he would be "His Excellency" and High Commissioner of South Africa; and Lord Kitchener was a cavalry major in Egypt, after a spell of obscure, if useful, survey work in Cyprus.

No earnest worker need fear that his present task is fruitless. "Thoroughness is the foundation of success," says one of America's best business men. No one can expect real success unless he is now laying, by faithfulness in the present little things, a foundation firm enough to stand on when the opportunity comes to reach up into higher spheres of action. Remember that fifteen years hence will probably have brought you your opportunity, and be always now doing your duty and thus preparing for your future.

Censure and criticism never hurt anybody. If false, they cannot harm you unless you be wanting in character; and if true, they show a man his weak points and forewarn him against failure and trouble.—*W. E. Gladstone.*

"Live well," says Milton; "how long, how short, permit to heaven.

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A RAILROAD MAN'S ADVICE

Mr. R. H. Bowron, recently elected to the responsible position of general superintendent of the St. Louis Southwestern Railroad, was born in England in 1858, where he received a good public-school education. At the age of sixteen he settled down to business as the junior clerk in a large firm of public accountants in London, with whom he remained for two years.

In 1876 Mr. Bowron came to America and entered the railroad business at Pittsburg in a line of work through which many prominent men have risen—as telegrapher in the employ of the Western Union Telegraph Company. He rose, through work in the railroad supply business and a position as chief clerk to the superintendent of a southern railroad, to be superintendent of the Chattanooga Union Railroad, a position which he held for five years. From 1893 to 1896 he was again rising through the positions of chief clerk and trainmaster to that of superintendent of the Montana Division of the Great Northern Railroad, and filled that position and the superintendencies of other more important divisions until October, 1899, when he accepted service with the St. Louis Southwestern Railroad—the familiar "Cotton Belt Route"—as superintendent of a division. In March of the present year he was promoted to the post of the general superintendency of that important southern railroad.

R. H. BOWRON,
General Superintendent of St. Louis Southwestern Railroad.

Men who have had to rise without the advantages of a thorough technical education are unanimous as to its desirability. No help to advancement is so effectual as education, whether secured early or late in life. All successful men are agreed that those who wish to rise in life should secure all knowledge possible pertaining to their business. Speaking of the value of education to a man in the railroad business, Mr. Bowron says: "Education has been of the greatest possible assistance to me. Without this foundation, very few young men can realize their ambitions. In the present day a very much higher standard is required in all departments of railroading than was necessary a few years ago. For this reason my advice to all young men would be to acquire as good a general education as possible, and then, as soon as they have decided what business or profession they intend to follow, to acquire a technical education. There are too many young men in the country who have a general knowledge of many branches of different professions, without being competent in any one. There never was a truer saying than that 'There is always room at the top,' and the top can be reached, in the vast majority of cases, only by having made a close study of some one branch of the business. For men that have done this there is always room at the top.

"I ascribe my own success mainly to the fact that I have always tried to watch my employer's interests, regardless of the work involved. Loyalty in this respect always results, sooner or later, in gaining the confidence of the man employing you, and this in turn will assure permanent advancement."

"Knowledge cannot be stolen from us," says Elihu Burritt, the learned blacksmith. "It cannot be bought or sold. We may be poor, and the sheriff may come and sell our furniture, or drive away our cow, or take our pet lamb, and leave us homeless and penniless; but he cannot lay the law's hand upon the jewelry of our minds."

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THE POOR MAN'S CHANCE

By Ex-Senator John J. Ingalls

One summer evening in pensive thought I wandered, fifty odd years ago, with a schoolmate under the "butterwoods," in Haverhill, on the shore of the moonlit Merrimac.

We talked long, as thoughtful schoolboys will, of the mysteries of the universe and the enigmas of destiny. To our defective forecast the future appeared dark, troubled, and uncertain. Time's golden age was behind. The battle for fame and fortune was more desperate.

We did not know, we could not know, no one knew, that we were standing at the portal or the threshold of the most marvelous age of the world's history; an age of such incredible achievements in science, war, wealth, luxury, and national power, growth, and glory, that by comparison the most exaggerated fables of fiction, the lamp of Aladdin, the purse of Fortunatus, the philosopher's stone, seem like the trivial commonplaces of the nursery, and the wildest hyperbole becomes tame and prosaic.

Looking backward across the years since that moonlight stroll on the banks of the enchanted river, I do not see that I have been denied any right, privilege, or opportunity enjoyed by those who have drawn the great prizes in the lottery of life—we all had the same chance. If laws were unjust, all alike were their victims. If statutes were beneficent, none were debarred their advantage. Those who climbed the highest began lowest. None were favored by legislation or influence.

Lincoln and Grant, neither suspected of greatness, were waiting in homely indigence the summons that, ten years later, was to call them to immortal fame. Edison, the mightiest magician of the forces of nature, was a tramping telegrapher. Carnegie was a messenger boy in Pittsburg. Huntington was selling picks, nails, and horseshoes in Sacramento. Jay Gould was a book agent in Delaware County. The Rockefellers and the mob of plutocrats that excite the envy and arouse the indignation of those who have failed, all began in the lowest and humblest ways of life.

I had the same chance, and every boy of that time had the same chance. The world was all before me where to choose, and Providence my guide. I had the right to build railroads or to go into Wall street and wreck them; to invent the telephone; to write Uncle Tom's Cabin; to mine for gold or silver; to concoct patent medicines; to corner petroleum; to bull pork and wheat, like my contemporaries. The only thing I lacked was brains. I didn't know how; so I went west and helped lay the foundations and build the superstructure of the great empire of the Northwest, and thus missed the whole show.

What chance has the poor man in 1900? About the same, I should say, he had fifty years ago. In some ways rather better if he can adapt himself to the changed conditions of society. Many avenues open then are now shut. Many opportunities once free, no longer exist. Competition is more selfish and strenuous, but the world was never so ready as now to pay for what it wants. There has been no time when the man or woman who can do anything better than anybody else was so sure of instant recognition and remuneration.

Paderewski and Irving have just sailed away with fortunes earned by a few months of professional exhibition. Mme. Nordica received a thousand dollars for singing two songs that occupied ten minutes, while an equally meritorious seamstress earns twenty-five cents for ten hours' repulsive toil in a sweatshop. Kipling gets more for a stanza than Milton did for the copyright of "Paradise Lost." Millet and Meissonier derived from the brush and the palette the revenues of the treasuries of kingdoms.

The poor man's chance, then, depends very much on what the poor man has to sell. If his stock in trade consists of untrained muscle, a dull brain, and sullen discontent, he will work for wages, dine from a tin bucket when the noon whistle blows, and die dependent or a mendicant. If he have courage, industry, enterprise, foresight, and the willing mind, he will gain competence or fortune. He will establish his family in comfort, educate his children, and accustom them to the environment of refined habits, which after all is the best of life.

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The real difference in men is not in want of opportunity, but in want of capacity to discern opportunity and power to take advantage of opportunity.

This, at least, is certain, that in 1950 the celebrated scholars and teachers, the learned divines, the eloquent orators and statesmen, the foremost legislators and judges, the President, who will have been inaugurated the year before, the great authors and poets and philosophers, the inventors and merchants and lords of finance will be men who are now young, poor, and obscure, striving against obstacles that seem insuperable to enter in at the straight gate that leads to fame and fortune. Society is reenforced from the bottom, and not from the top. Families die out, or fortunes are dispersed, the recruits come from the farm, the forge, and the workshop, and not from the club and the palace. Those who will control the destinies of the twentieth century are now boys wearing homespun and hand-me-downs, and not the gilded youth clad in purple and fine linen, and faring sumptuously every day at Sherry's and Delmonico's. This is the poor man's chance. It is open to all comers. It is not a matter of law, or statute, or politics.

ELEVATOR CUSHION STOP.
Invented by an I. C. S. Student.

A NEW ELEVATOR SAFETY CUSHION

One has only to scan the daily papers to read of elevator accidents and to realize the necessity of a reliable elevator stop to prevent fatal accidents. A Kansas City man has invented a new and practical pneumatic cushion for elevators, which, under severe tests, has proved its ability to bring the falling cage to a gradual stop, no matter what the speed of the descent may be.

The device is identical in principle with the small air cushions in common use to prevent the slamming of heavy doors, and is the invention of Mr. E. S. Miller, a student in The International Correspondence Schools.

This stop does not interfere in any way with the regular running of the elevator. It is simple, strong, and durable, of inexpensive construction, and may be mounted in proper position with little difficulty. It consists of a pneumatic cylinder mounted vertically and centrally in the shaft and extending upward toward the lowest stopping place of the elevator. The lower end is closed by a flange held firmly in place by heavy bolts extending through the foundation.

A rod about the same length as the pneumatic tube and running vertically downward is bolted rigidly in the center of the bottom of the cage. At its lower end is a piston fitting snugly in the tube when the car passes lower than its lowest regular stopping place. The tube is flared at the top, to insure the proper entry of the piston. It is also provided with two automatic, adjustable exhaust outlets, one above the other, to permit first the rapid and then the slow escape of air.

The device causes a gradual stoppage of the cage, as when the piston first enters the tube it has a double exhaust, but soon passes the first outlet. Then, when the force of the fall is broken, there is a greater compression of enclosed air and cage settles gradually to a stop.

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EDUCATION THE BEST ASSET

Next to Character, said the Hon. Timothy L. Woodruff, in a recent address, a man or woman's best asset is Education; and the broader, and better, and deeper it is, the more truly and surely can he or she resist the perils which in these days of fear and sophistry present themselves to him or her in all the walks of life. A trained intellect is of inestimable value, whether its energies are to be devoted to legal and philosophical pursuits or the activities of commercial or mechanical life.

As a practical business man, let me talk plainly. Above all things, never be lazy—to the lazy every petty cross that impedes his onward path is Fate. Fate is as much cursed by the indolent as Luck by the envious. In the palmy days of youth, when it is natural to be active, one should put forth his best endeavor.

The most important thing in business life is to make a good start by carefully determining what one's capabilities best fit him to perform. If you have not the proper qualifications to make a first-class bookkeeper, do not try to keep books; and if you have not an adaptability for stenography and typewriting, leave shorthand and the typewriting machine alone. If you find that you lack that peculiar characteristic ordinarily termed magnetism, whereby one is able to control men, do not take a position as a salesman, and unless you have a natural instinct for barter and a thorough knowledge of the value of a dollar, do not be a buyer. When you have decided what kind of a position you are best qualified for, and enter upon your life-work, keep your eyes and ears open. When you are going about, make all the good acquaintances you can, and learn how others have succeeded. Do not build air castles or play the part of a wool gatherer, but spend your time in observing everything about you, even if you do no more than familiarize yourself with the location of streets and places of business, so that when you are sent out by your employer you can perform an errand quickly. I know a young man who got a place at a few dollars per week, and laid the foundation of a successful business career by happening to notice a sign across a building, "To rent." The owner of the warehouse, whose name was on the sign, happened to be the father of one of the young man's college friends, and through this relationship he became the lessee of the property. Had he not noticed that sign, no similar opportunity might ever have presented itself to him. In fact, in nothing is the old adage that "Great oaks from little acorns grow" more true than it is in the grasp of opportunities in business. One can never afford to let even a single opportunity slip. You never know which one may be *the* opportunity of a lifetime. Then, too, it is much more difficult after the loss of one to secure and utilize another opportunity. For these reasons I urge you to put forth your best endeavors in the first position, the duties of which are entrusted to your care. Put up with almost any inconvenience or discomfort from irritating surroundings rather than run the risk of being a rolling stone. Acquire the characteristic quality of the postage stamp—to stick till it gets there. While you are at work do not let your mind be diverted to thoughts of pleasure, and when you are taking pleasurable recreation, do not think of business. In other words, work hard and play hard.

The real secret in commercial life is embodied in a willingness and an effort to do something more than merely routine work of one's position. Zeal attains the zenith! The truly successful men and women are not in the class of those who simply do satisfactorily the work assigned to them. It is the man or woman who shows a disposition to avail himself or herself of every opportunity to do work that some one above him or the employer would perhaps have to do, that is on the high road to success.

I sincerely believe that the future of our country lies in the thorough education of her people, and that not only the schools which teach the absolutely necessary elementary subjects, but also the places of technical education whose work it is to broaden his ideas and give him new lines of thought, are the means to attain that end. Surely the graduate of the business or technical school, with all the benefits of the greatest economists, and the practical application of those theories, ought to be able to enter the arena of practical life, better armed to carry on the battle of life, and at the same time more thoroughly equipped to defend and promote the institutions of his country.

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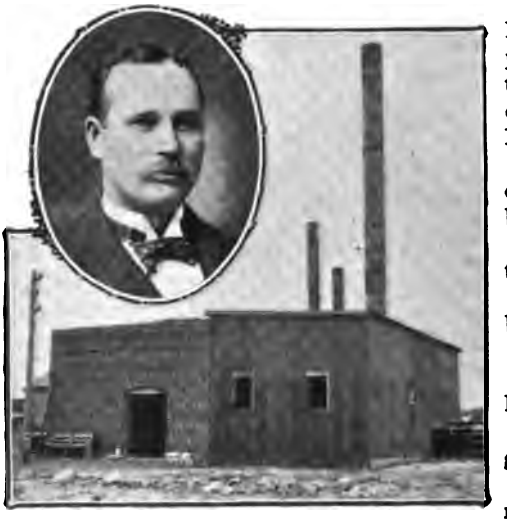
INSTALLED BY A CORRESPONDENCE STUDENT

The accompanying illustration is a photograph of the electric light plant of Walsenburg, Colorado, recently installed by Mr. Fred E. Ramsay, Superintendent of the Walsenburg Electric Light Company and a student in The International Correspondence Schools. The plant uses 110-horsepower high-speed engines with 190 horsepower boilers, comprising a 100-horsepower Heine water-tube boiler and a 90-horsepower return-tubular boiler.

In his boyhood, Mr. Ramsay had no opportunity to get an education. When but seven years of age he went to Colorado with his parents. In those days schools were few and far between, and the chances for Colorado boys getting a good schooling were very slim. Young Ramsay got but little benefit from what little schooling he had, for there were but four months of school during the year and he had to walk three miles across the prairie to reach the little cabin where school was held.



ELECTRIC LIGHT PLANT INSTALLED BY MR. FRED E. RAMSAY, AN I. C. S. STUDENT.

At the age of eighteen he decided to become an engineer, obtained employment in a roundhouse on the Chicago, Burlington & Quincy Railroad, and then worked himself up from wiper to engineer.

In 1888 he left the railroad to accept a position as engineer of an electric-lighting plant, where he soon discovered that a man with little education, however ambitious he might be, had a very limited field in which to work, and could not compete with men of fairly good education.

Mr. Ramsay was about to return to railroading, but happened to state his case to a friend, who advised him to try a course of study in a correspondence school before relinquishing his position. Before accepting this advice he was doubtful about its expediency, but today expresses as his opinion that "The new system of education is the grandest thing ever placed within the reach of working men." Through his Course in Electric Power and Lighting he has not only risen to be superintendent of the Walsenburg plant, but has invented and obtained United States Patents on two ingenious devices for regulating incandescent electric lamps, and declares that "Had it not been for the Schools and the successful methods of teaching employed by them, I could never have perfected either of my inventions."

ROTHSCHILD ON SUCCESS.

In one of the private letters of the late Alphonse de Rothschild, these maxims of success of the great house of Rothschild are found:

Carefully examine every detail of your business.

Be prompt in everything.

Take time to consider, but decide positively.

Dare to go forward.

Bear troubles patiently.

Be brave in the struggles of life.

Maintain your integrity as a sacred thing.

Never tell business lies.

Make no useless acquaintances.

Never appear something more than you are.

Pay your debts promptly.

Shun strong liquor.

Employ your time well.

Do not reckon upon chance.

Be polite to everybody.

Never be discouraged.

Then work hard, and you will be certain to succeed.

"Idleness," remarks Feltham, "is the most corrupting fly that can blow on the human mind. Men learn to do ill by doing what is next to it—nothing."

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THE MECHANIC'S OPPORTUNITY

By John Henry Barr, M. S., M. M. E., Professor of Machine Design at Cornell University, Ithaca, N. Y.

It no doubt requires much energy and perseverance to do real studying after a hard day's work in the shop or engine room, but those who have the physical, mental, and moral strength can certainly derive great benefit from such courses as can be conducted by correspondence.

I am not one of those who consider a technical-school education as absolutely essential to a creditable engineering career. I have seen too many successful engineers who have given themselves an education, to hold such views; there is no question but that the man with the scientific training is more in demand than ever before, and he who lacks such advantages will be greatly handicapped in the future. With the correspondence school ready to help him, the ambitious young mechanic who cannot go to college has a means of advancement within his reach. What he gets out of it rests largely with himself.

I have frequently expressed an opinion similar to the above, when questioned by men who were thinking of taking a correspondence course, and have recommended it to those who have the grit to drive themselves.

USE YOUR MINUTES

Comparatively few men have an adequate idea of what can be accomplished in their odd moments. Self-improvement is an up-hill fight, but there is not the man living who cannot win if he looks after the minutes. The results that pile up through careful use of time are well illustrated in the following conversation recently reported in the New York Mail and Express:

"I can't do it. I haven't time enough."

"Yes, you have."

"I don't see how you make that out," replied the first speaker, who was discussing with a friend the advisability of taking up a certain course of scientific study. "I work at my desk in the office from 9 o'clock to 5 o'clock every day except Sunday; and I must take recreation in the evening."

"I'll prove to you that you can. You get up at 6 o'clock, say, have breakfast at 7, and finish at 7.30. That gives you an hour to study before going to work. You have an hour for your luncheon, and then you manage to spend another hour every afternoon over your pipe and newspaper, don't you?"

"Yes."

"With less time than that Garfield became a classical scholar, Gladstone became one of the mostly widely read men in the world, Disraeli made himself a famous author, and Edwin Arnold wrote his 'Light of Asia.'"

"Yes, but they were men of genius."

"True; the genius of hard work. I will cite another case of which I have a personal knowledge. Some years ago I knew a bright young man named Leslie Bulgrove. He was post-office clerk in Indianapolis, Indiana. He was one of the most accomplished men I ever saw. He devoted his three hours of leisure every day to various pursuits. He divided them with unvarying method. The following is what he did in five years: He read and committed to memory all of Shakespeare's plays. He could read Latin, Greek, and French fluently. He was an expert flute player. He was one of the best natural historians I knew. In addition to this he was proficient in every line of fencing and marksmanship, and although he did not weigh more than 130 pounds, he could strike a ninety-pound blow with his fist. He simply in turn devoted half an hour a day to each subject. He kept this up unremittingly for five years, and finally attained such a degree of proficiency in each that he might have been called a master. The secret of his success was hard work. He wasted no time. It is true that he might have devoted his time to more profitable studies; and had he done so he might have made a great name for himself. I only instance his case to show you that you, and almost every man of your acquaintance, waste enough time every day to make you great should you devote it to its proper use."

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THE TRAINING OF YOUNG MEN FOR MECHANICAL WORK

By Lieut. James Blake Cahoon, Consulting Engineer

Lieut. James Blake Cahoon, of Syracuse, N. Y., the author of this article, is one of the best-known men in the electrical industries, being President of the National Electric Light Association and member of both the American Institute of Electrical Engineers and the American Society of Mechanical Engineers. Mr. Cahoon has had much experience of a practical nature, being known both as a careful man of affairs and popular with all. Throughout his career he has served in responsible positions, and has uniformly acquitted himself with credit wherever his counsel or his active cooperation has been asked for. He makes a specialty of plans and specifications for and construction of electric, gas, water, and street-railway plants and their economical combination; of isolated and long-distance transmission plants; the remodeling of factories and plants; investigations and reports for financial institutions and municipalities; expert testimony, and the management of properties.

Some little time ago I had occasion to visit one of the larger all-round machine shops where general manufacturing and repair work was done, and the question of apprentices came up for discussion with the manager of the shop. He said that he had very few applications from young American boys to learn the machinist's trade, and that at least seventy-five per cent. of the applicants were foreigners. This carried me back to the days when I was manager of the expert department of the old Thomson-Houston Company, when we took young men into the works and gave them a practical training in order that they might go out as experts and install electrical apparatus. There the conditions were just reversed, for fully ninety per cent. of the applicants were American. As opportunity has afforded, I have been looking into this question, and I find that the experience of the machine shop in question is not exceptional. The American boy, as a general rule, seems inclined to avoid the trades, and is striving for either a collegiate education or a mercantile life. The United States leads the world today in manufacturing industries, and it has reached this high plane by reason of the dexterity and skill which the American has shown in various lines of trade, in inventing machines which do the work of many and cheapen the cost of production to such an extent as to enable our people to pass other nations in the race for manufacturing supremacy.

Lieut. James Blake Cahoon.

Germany, England, and France are today far in advance of this country in the matter of trade schools and the education and training of their young men for the trades. We are just beginning to agitate the question here, and it is being forced home to our convictions that unless we speedily take some active steps in the matter the next generation will see the present status reversed. I believe it would be a most excellent thing for this country if every young man were required to learn a trade, even if he did not follow it subsequently. Many of the leading professors in our educational institutions hold to the idea that the learning of a trade is not at all necessary, and particularly is it unnecessary where an engineering education is to be given a young man. They hold that the machinist belongs on one level, that the mechanical engineer belongs on a higher and broader level, and that there is no passing from one level or stratum to the other.

Some years ago I wrote an article for one of the electrical magazines on the training of the electrical engineer, and in it I stated that the experience I had in dealing with the graduates of our colleges and technical schools taught me that there was something radically deficient in the methods of teaching in vogue, for with the exception of those from a single institution, there was not one whom I could trust to go ahead and lay out a piece of work and do it. They seemed to have little or no conception

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of the use of tools and what could be done with them, and I strongly advocated that more attention be paid to practical work and careful instruction be given in the use of shop tools.

In reference to electrical engineers, I stated in that paper as follows: "Perhaps the best course of instruction in practical work that could be given would be to give the students, three or four hours a week, instruction in wood-working machine tools, etc., at the same time providing for a course of lectures by the leading foreman of some large machine or electrical works that may chance to be near by, and then supplementing this by having the students placed, say for two months each summer, at some electrical works where they could take a portion of the student course as given in such works." This student course would include practical work in making the parts, assembling, and testing machines.

This, however, applied only to young men who were taking a college course in engineering. The majority of our young men are unable for various reasons, the one of expense largely predominating, to take a college course if their inclinations lead them toward the mechanical trades or engineering. We want today bright American young men as machinists; we want them as foremen and as draftsmen in our works and in our patent offices. Only the other day a patent lawyer who has an office near mine stated that it was almost impossible to get a good American draftsman for his work. He said what he particularly wanted was some good, bright young fellow who would get hold of the idea of a patent and work it out without running to him every minute and asking a million questions.

A man known to be a first-class mechanic, who can be relied upon, is a valuable addition to any community and is respected by everybody, and young Americans make no greater mistake than to think for a moment that they are lowering themselves in any way by learning a trade. I have often heard men who are clerks in stores spoken of in a contemptuous way, but I have never heard a first-class mechanic spoken of in other than terms of the highest respect. Why, then, should the American boy think it beneath him to learn a trade? Are they not making the greatest mistake in the world when they think in this manner?

Success, in the trades as in everything else in life, means work, attention to details, and willingness to work for the interests of the employer at all times. In other words, if a young man goes into a shop, takes an interest in learning a trade, and works for the interest of his employer, he is bound to succeed. Success does not, however, lie before the young man who thinks he must go to balls and parties and be away for a good time, be in at his work late in the morning, and be careless and indifferent in the way he does that work. Let him work first to learn his trade thoroughly, then supplement it by education through home study, and it will be found that the young man who follows this rule will speedily jump to the front and occupy a leading position in the trade he has followed.

Many young men have asked advice as to how they should gain additional information in their particular line of work. They say frankly that they cannot afford to go to a college and spend the time and money necessary to take a college course, and although they take one or more technical papers and read them carefully, and study such books as seem to bear on the subject, they do not make the progress they want. To these I reply—and I know of many others who have told young men the same thing—that by taking a course of instruction from one of the correspondence schools, they can, by devoting even an hour a day to the work, in time become thoroughly grounded in the line of work which they are following, and have the great advantage over the college man of having the practical experience and knowing just what they want to get, thus studying intelligently and learning in a way that they will never forget.

One of the best mechanical engineers I know of in the United States, at the head of the mechanical department of one of our large manufactories, cannot write "M. E." after his name, because he never had a day's college education; but that man followed just the course I have spoken of, and when it comes to the settling of an engineering problem, I know of no man today whose opinion I would rather have than that man's.

And so, in conclusion, I want to say to the American young men of today who would naturally go into the trades, do not let yourself

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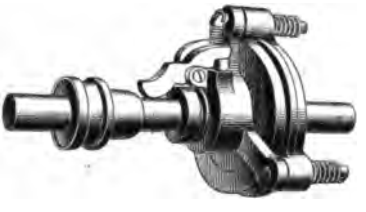
be diverted by any false or sentimental ideas that a trade is not an honorable occupation. If you think you are naturally fitted for a particular trade, go into it and learn it thoroughly down to its very last detail, supplement that with careful, intelligent study under the direction of some good correspondence school, put aside frivolity, and work with the distinct end in view of becoming the master of your trade. If you will do this, success is yours, and in benefiting yourself and succeeding, you will benefit the whole community, and in so doing will do your share toward making and keeping our country the greatest manufacturing country in the world.

A NEW FRICTION CLUTCH

The clutch illustrated here was invented by Mr. E. J. McCarthy, of Clinton, Mass., a student in the Complete Mechanical Course of The International Correspondence Schools.

Some of the principal features of this clutch are that the construction is simple and of great



FRICTION CLUTCH
Invented by an I. C. S. Student

strength, making a solid connection, holding the sections of shafting firmly together, and saving all loss of power. Once placed in position, it requires no care or setting, and is easily operated at any rate of speed. Its size ranges from six to forty-eight inches in diameter for from four to one thousand horsepower. It is used on steam engines, waterwheels, dynamos and motors, cotton and woolen machinery, wood-working machinery, in pumping stations, and other places where power is used.

Mr. McCarthy, the inventor and owner, has been kept busy for several months supplying the market with the new clutch, which is meeting with great success. He is the inventor also of a machine for making window screens and a women's brush skirt binding, and is steadily rising in the manufacturing world, in which he is considered a mechanical expert.

From his Course he says he has secured many ideas that he has put into his inventions, and without which he would many times be at sea. Before enrolling, he was unable to perfect anything, but has since gained power to successfully handle his inventions in person, and secure a considerable income from them.

KILLING TIME

"When I was a boy in a printer's office," says Robert Bonner, "and it came along about three o'clock in the afternoon, I would say to myself, 'Suppose the proprietor should come up where we were at work and say, "Robert, what have you been doing today?" what would I answer?'

"He never did such a thing, but I used to reason to myself, 'Suppose he was to do it?' If I could not, with pride and pleasure, point to what I had been doing, I would pack up at six o'clock and leave the place. I consider that kind of spirit is an element of success, and there is always room for men who show that kind of disposition. The indolent man, who shiftlessly goes through his day's work, will never reach the goal of success. The man who is constantly watching the clock, waiting until it shall strike six, and trying to 'kill time'—well, it will not be long before time will kill him, so far as business is concerned."

IN ENGINEERING, CHARACTER LEADS

"We must recognize the fact," says Dr. R. W. Raymond speaking of the means of education in technical schools, "that individual character is, after all, the decisive element in success. We may devise plans without end to facilitate the manufacture of successful engineers, but the men who have fidelity, honor, virtue, courage, and that genius which has been well defined as the power of application, will make their way surely to the top, either by the help of our arrangements or in spite of them all; and of those born and bred leaders of the profession, those who have the broadest culture, other things being equal, will stand easily first."

"Reputation," says Lowell, "is in itself only a farthing-candle, of wavering and uncertain flame, and easily blown out; but it is the light by which the world looks for and finds merit."

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FROM DRAFTSMAN TO GENERAL MANAGER

The twenty-page illustrated catalogue, just received, of the Lake Shore Engine Works, of Marquette, Mich., manufacturers of the "Superior" gasoline motors, shows vividly benefits of the most substantial sort accruing to a young man from a course of study persistently followed out.

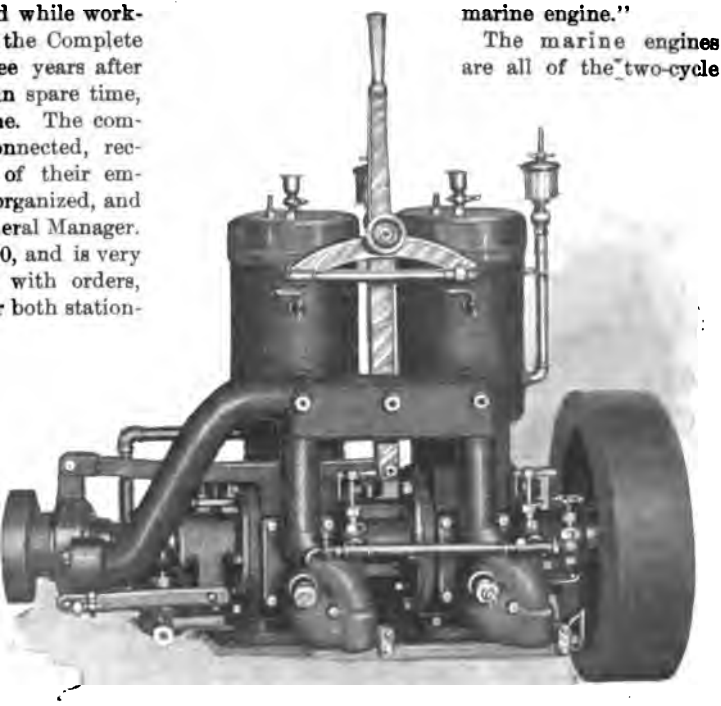
C. H. BLOMSTROM

The brilliant success of Mr. C. H. Blomstrom, Director and General Manager of the Lake Shore Engine Works, should be an inspiration to all who are sacrificing hours of rest and recreation in order to secure in a technical education the means by which to push to the front.

Mr. Blomstrom is now taking the Gas Engines Course, but previously, and while working as a draftsman, took the Complete Mechanical Course. Three years after enrollment, he invented, in spare time, the "Superior" gas engine. The company with which he was connected, recognizing the possibilities of their employe's invention, then reorganized, and made him Director and General Manager. It has a capital of $100,000, and is very successful, being overrun with orders, making gasoline engines for both stationary and marine service.

Their double-cylinder marine motors, illustrated on this page, are so compactly built as to be adapted for use in small boats requiring great motive power, and are successfully applied to life boats. The United States Government has recently adopted the "Superior" engine for its life-saving service on the Great Lakes. "The necessity for a life boat with power has long been recognized both in this country and in Europe," says Marine Engineering, in a recent issue, "but because of the peculiar work required of the life boat, the problem has been difficult of solution. The British Royal Life-Boat Institution has been working on this problem for several years, with doubtful success, having built several steam life boats. But a boat with steam power, if capsized and rolled completely over, as life boats frequently are, would have but little assistance from its engine afterwards. Experiments have been recently made by the United States Life-Saving Service with the 'Superior' gas engine in a 34-foot life boat, this engine being selected because of its lightness per horsepower, simplicity of construction, compactness, and its ability to run under adverse circumstances. It is the unanimous opinion of the officers of the Service that the Service would have a very valuable auxiliary by the general adoption of the 'Superior' marine engine."

The marine engines are all of the two-cycle



"SUPERIOR" DOUBLE-CYLINDER 8-HORSEPOWER MARINE MOTOR
Invented by an I. C. S. Student

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type, and the stationary engines of the four-cycle type. Mr. Blomstrom has produced a neat, simple, symmetrical, and perfectly proportioned motor. It uses nothing but true mechanical motions, without small or intricate parts liable to break at a critical moment. The engines are made in sizes from one-half to one hundred horsepower, and include many ingenious devices designed to secure the greatest simplicity of construction and the least possible number of parts.

Another "Superior" success is a horizontal pumping engine for land service, the motor and pump being both combined on one base.

Mr. Blomstrom is very enthusiastic over the work of the Schools, and says "Without the knowledge gained from your Course of study, I would never be where I am today." He is consequently very anxious to have all his employes take up Courses of study, and is always willing to give students the first chance for promotion.

A REVEALER OF CHARACTER

By Frederick E. Burnham

Several months since a business man advertised for "a man willing to work." His experience with the applicants for the position is best told in his own words.

"I had been repeatedly disappointed in those I had hired in the past," said the merchant; "one was dishonest, as I discovered to my cost, another was not punctual, and a third careless.

"Finally I came to the conclusion that it would pay to devote a morning to the purpose of selecting a trustworthy man; and this I did. The results were interesting.

"When I arrived at my office, half a dozen men were already in waiting. One at a time I called them into the office, beginning with the first in the line. One glance at the foremost settled his case; he wouldn't look me in the eye. I told him I should not need him. I suppose he is still wondering why I was so short with him.

"Next came a young man armed with a double-barreled recommendation from his pastor testifying to his good character and business ability. I looked at the youth several times, read the recommendation again, and finally came to the conclusion that either his pastor was no judge of human nature or the paper was a fraud. Those listless, vacant eyes told me that we could never hope to get along well together. I dismissed him.

"The third one interested me the moment he stepped inside the door. He was poorly dressed, though his clothes were whole; his suit was at least two sizes too small. It was evident that his attire troubled him not in the least, for he held his head high, and as he approached my desk he looked me square in the eye. He said that he had no recommendation, and had had no business experience, but that he was willing to do his best to please me. In an instant it dawned upon me that before me was the man I was looking for. He had nothing to recommend him save an honest, bright eye and a pleasant face; but that was sufficient. I engaged him on the spot.

"Since then I have seen fit to advance him over the head of a man who has been with me for three years. The latter grumbled, but there was reason for my move—the new man had proved himself worthy of promotion."

Instances might be indefinitely multiplied of the value of an honest eye. That wonderful window of the soul, the eye, is a sure index to character.

Cultivate it! It is worthy of the greatest effort. Look up and fearlessly meet the eyes of those with whom you converse. There has been many a choice position lost through an indifferent, flinching eye; and there has been many a coveted position won through a fearless, honest eye. That kind of an eye is better than a hundred recommendations.

"All the means of action," says Henry W. Longfellow, the famous poet of New England, "the shapeless masses, the materials, lie everywhere about us; what we need is the celestial fire to change the flint into the transparent crystal, bright and clear."

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ENGINEERS MUST THINK AND STUDY

By Charles J. Mason

Any person who has been employed in a machine shop, at the constructing and erecting of steam machinery, or engaged in or about a steam plant of any kind, and *thinks* he can safely assume the duties of an engineer, should *examine himself* and see if he *really* is capable, and has sufficient knowledge—of the right kind—before assuming such a position. In some of the States there already exists a law governing the licensing of engineers to operate and take charge of steam boilers. An applicant *must* present himself before a duly appointed inspector or examiner, and pass an examination as to his qualifications to act as an engineer. Should he fail to do so, and still accept the position offered him, he is liable to be severely punished.

There are some States in the Union which have not any license law, and an employer can engage almost any person he cares to; of course a man engaged in that way may or may not be competent, but in many cases any person who claims to be an engineer, and can show that he has worked in such and such a plant, is engaged, and in time is found to be *not* competent. A man may take charge of a plant which is in fair shape, and by simply *not* touching anything excepting the starting bar and throttle valve may continue in that position for quite a time; when a breakdown occurs (which possibly could have been prevented had an *engineer* been in charge) he knows not what to do, nor can he give directions to those who may be about him. Such a man will refer you to his "time of service," he will tell you "nothing ever happened like that before," and such like explanations.

Now, whether in a place subject to license laws or not, it should make no difference to a man who wishes to hold an engineer's position; he should qualify himself for that position by experience and study. Simply by "putting in" so many hours per day doing a certain kind of work in a plant, and then going home to forget all about it till the next day, will not aid him very much. Steam Engineering is not like a trade in which a boy is placed for a number of years, doing certain things every day according to instructions given him by a foreman or leading man and need not bother his head after he leaves the shop. On the contrary, one *must* bother his head about things which he will not learn in a machine shop or engine room, if he wishes to be even an "ordinary" steam engineer. In short, there is a great difference between an *engine driver* and an *engineer*, but the engine driver *may* become an engineer if he wants to, by learning the ins and outs of his business, and not merely being contented with starting and stopping his engine, and a few other routine duties.

While it would be of little use to give a student a list of questions and answers to learn by rote, as a schoolboy would learn "a piece," yet, by actually *studying* the things suggested by such questions much knowledge may be acquired. The mere fact of having learned by heart the answers to a certain set of questions is of no permanent benefit, not even if such a person actually managed to pass the examination given him, for he may have to go through another at some future time, and get an entirely different set of questions. If he had *studied the principles* and *the elements* of the questions, he would be able to give a satisfactory answer no matter in what *form* the question may be given.

It must be borne in mind that no amount of *mere reading* of anything is of great value. You must read and think over what has been read, again and again; turn and twist it, mentally, into every conceivable shape and form. Argue with yourself about it, make diagrams of it for yourself, and try to find out all there is in it. You will be surprised at the task before you. Many times you will be obliged to stop at some point in a problem, owing to your ideas becoming confused; well, stop, drop it for a time, but go at it again. Each time you resume, it becomes easier, clearer. Of course, all this is hard work, and while there are ways and means whereby hard work is made *easier*, yet for all this, even the *easy* ways *must* be worked at diligently and hard if success is desired.

Engineering is not an easy profession. Those who have entered it with that idea have made

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a mistake which will be brought home to them day by day. They see others go by them to better positions, and wonder how it can be. They blame everbody concerned—except themselves. In many cases men fail simply because they will not take the *trouble* to fit themselves for better places. If such places could be obtained *easily*, then they would be sought for eagerly. Therefore, do not be content with holding a position where you have to fire a boiler, and see that a certain quantity of water is kept in it; or start and stop an engine every day, and keep it oiled; and occasionally adjust the different parts. All this is very essential and requires to be done right and well; but it is only a part of what you should know and do. You should not only know *how* to do these and other things, but you should inquire *why* they are done, what would be the result if they were *not* done, and *how soon* such results would appear.

Such thoughts as these should constantly occupy your mind. One thought will suggest another, and another in turn; and you will find in time that, when you become fully aware of the mighty and dangerous forces over which you have control, you will be obliged to take your "thoughts home with you," in order to cope with or prevent any mishap which is liable to attack the machinery under your care. This is what makes an engineer of you, in reality. You will be living, to a great extent, in the future. The present condition of your plant is the result of thought of some time past. It is plain, an engineer *must* be a thinking man.

EQUAL TO THE EMERGENCY

Mr. Camden J. Weller, a student in the School of Electricity, has succeeded in putting in operation an electrically equipped larry, or car used for charging the coke ovens, at the Leckrone, Pa., works of the Eureka Fuel Company.

The larry just put in operation is equipped with a General Electric motor of 27 horsepower capacity and holding 175 tons of coal. It has the regular trolley pole used by the General Electric and Westinghouse Companies, except that the trolley pole is arranged on the side of the larry, the trolley wire being 23 inches outside the rail. The controller is the regular General Electric street-car controller.

It is not such a notable feat to put such an equipment in service, if everything needed is at hand, but in this case Mr. Weller had nothing but the poles and arms on the ovens. From the ovens to the bin where the larry is filled, a track was constructed containing a curve of 80° radius and another of 100°. Upon this portion of the track he erected temporary wooden poles and wooden arms. The complete equipment for this installation had been ordered for some time, but had not yet been received. A large number of ovens being already finished, and no means of charging them except by the electric larry, Mr. Weller set to work to devise some plan by which he might carry on the work with what material he could find or make until the regular equipment came, and incidentally to prove that he was equal to the occasion. The poles and arms on the ovens were made of 2-inch iron pipe. To the arms he clamped wooden blocks, and screwed home-made trolley-wire hangers to the blocks. He also made his own strain insulators and the pull-over clamps used on the curves. For a trolley wire he used a No. 2 bare copper wire that happened to be on hand. The track contained a switch which necessitated the construction of a frog, or switch, in the trolley wire.

Mr. Weller writes: "It is surprising what good service we are getting out of this arrangement. It is being worked every day, and bids fair to continue to do so until the material for the proper installation arrives. We will eventually have six motor-driven larries at work. In addition, the mines, the haulage equipment, and everything requiring power about the works is to be electrically equipped.

"I am the electrician for the company, and have completed the work spoken of without having had any previous experience in traction service. All my past experience has been in electric-lighting lines. All the knowledge I have about electric-railway construction I received from my Course of Study in Electric Power and Lighting."

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NO SUCCESS WITHOUT AMBITION

The trait of character that Webster defines as "an eager desire for the attainment of something," though much spoken against by moralists, is in fact absolutely essential to success in life. The difficulties environing the pathway to any great accomplishment are so tremendous, the pathway is so arduous, that the man who is to succeed must burn with eager desire, if he will rise superior to all obstacles.

Every student should determine upon some object of ambition so great and desirable as to be worthy of every effort to win it. No matter what his present position, he must aim high, to make any kind of a success.

Ambition will win you the notice, approval, and assistance of those in higher positions. "I like," says Senator Chauncey M. Depew, "to see a shoemaker cobbling who has an ambition to own a shoe store. I like to see a blacksmith who hopes to own a hardware store. I like to see a newsboy who hopes to be a great editor. I like to see a clerk who hopes to be proprietor of a store. I like to see ambition in all men. I like to see egotism in men, because it shows ambition."

Be careful, after setting your aim high, to lay a foundation broad and deep on which to build your career. Study exhaustively the principles and practice of your chosen line of action.

Don't aim at a small thing, if you have within you the power and endurance to accomplish something greater. If you plan a woodshed and then find you have strength to build a temple, you will never be able to build the temple, for lack of materials you might have accumulated had you made the temple your first aim. The world may call you successful when your woodshed of inferior achievement is built, but you would give all you have won to be able to make up for the lack of preparation that would have made your life a grand, satisfying success.

ANNOUNCEMENT

We take pleasure in announcing that the gold watch offered in the June issue of SCIENCE AND INDUSTRY to the club raiser securing the most subscriptions before September 1, has been awarded to Mr. H. C. Gillespie, 1856 Eighth Ave., Huntington, W. Va.

INFORMATION WANTED

Information is wanted about what students of The International Correspondence Schools are doing in the world of industry. If any student is engaged upon an important installation, or a civil, mechanical, or electrical engineering enterprise of any kind, we would like to be informed about it. Descriptions of machinery designed by students are always acceptable. We desire to receive notes about buildings planned or erected by students. Inventions and patents, important advancements in position, anything, in fact, that will be news about our students, we wish to receive word of. As far as possible, accompany your descriptions with your own photographs, and with photographs, drawings, or sketches of the subjects of your descriptions. Address all such matter to G. H. Fisher, I. C. S. Dept. Editor of SCIENCE AND INDUSTRY, Scranton, Pa.

AN OPPORTUNITY

A splendid opportunity for club raisers for SCIENCE AND INDUSTRY is announced on page 35 of this issue. Look it up. It will pay you to act on its suggestion and begin to get new subscribers.

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OPPORTUNITY FOR CLUB RAISERS. See Page 35

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FORECASTLE TO RAILWAY SUPERINTENDENT

A Farmer Lad Rises to Prominence After Thirty Years' Endeavor

George W. Adams

In response to a request from the editor of this department, the following biographical sketch has been written for the readers of Science and Industry by Mr. George W. Adams, superintendent of the railways of the Hawaiian Commercial and Sugar Company, with headquarters at Spreckleville, Mani, Hawaiian Islands. Mr. Adams sends it "with the sincere hope that it may be the means of leading some young man to success."

"I was born, and lived," says Mr. Adams, "until the age of twenty-one, in Pownal, Cumberland County, Maine. My father was the owner of a large farm, but worked most of the time at his trade, that of a ship carpenter. Both my father and mother were very good people of high character, but both were uneducated, and therefore thought it a waste of time and money for a young man to spend four years in college. I attended the district school, and my desire for further advancement in book knowledge was rewarded by my being allowed to attend Litchfield Academy one term. I wished very much to attend Bowdoin College, which was only nine miles from my home, but to my earnest requests, seconded by an older sister's pleadings in my behalf, I received a decided denial from both my father and mother.

"At the age of twenty, after hiring a man to take my place on the farm, I shipped with Captain John Hodgden, of the good ship Bullion, as a green hand. I liked the sea, and Mr. Brown, the chief mate, who found out that I was quick to learn and good in mathematics, taught me navigation. In less than five years I was walking the quarter deck of a two-thousand-ton ship as second mate, with the promise from the owners of the office of master in three years more.

"While in port at New York I visited my home for a few days and found my father sick in bed, his first sickness, although at the age of seventy-one. In response to his and my mother's tears and pleading I returned to New York, gave up my position and brilliant prospects, and taking my goods, went back to my home, where I cared for my father until his death the following October.

"I had lost my position and was too proud to enter the forecastle again; I would not take up farming again, for I had learned to hate it, because I felt that it was the farm that had prevented me from going to college. I turned my mind, therefore, to railroading, and entered the employ of the Grand Trunk Railroad Company as a section hand on repairs of track. My desire to advance soon brought me to the notice of the road master. In boyhood, my father had taught me that what was worth doing was worth doing well—advice which I have never forgotten; I was soon advanced to positions of trust until I had one hundred and fifty men under my control.

"The Civil War broke out at that time, and I went to Washington intending to enter the army, but entered the railway service of the Government instead, as a fireman. In seven months I was promoted to engineer and placed on a new engine. I ran her a few months, when I decided that I did not know enough about a locomotive to make a successful runner. Much to the displeasure of the officers of the road, I resigned and returned home. I entered a machine shop, where I served my time learning the machinists' trade. I then entered the employ of the Maine Central Railroad Company as fireman, under J. W. Philbrick, master mechanic. In fifteen months I was again promoted to the post of engineer and after the experience of the preceding years I felt that I knew what I was doing. I worked for the Central a few months, when Mr. Philbrick wished me to go out to Kansas for his son, who was master mechanic of the L. L. & G. Railroad. I did so, and remained with him a year, when I returned to the Central again. Since then I ran all kinds of trains successfully for twenty nine years, until I accepted my present position of Superintendent of the Railways of the Hawaiian Commercial and Sugar Company.

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"I ascribe my success to an earnest desire to be faithful to my employers. I felt proud, after twenty-eight years of service, to be told by one of the officials of a great railway company that I had not in all those years caused one dollar's worth of expense on account of neglect or carelessness. I always made it a point never to give up anything that I had undertaken, unless forced to, until I had succeeded.

"Of technical education I have none, only as I have studied things out by the extremely difficult method of studying textbooks alone, with no assistance whatever. Being quick to observe and apt to apply, I find myself, however, in possession of much valuable information that assists me in my official capacity. I would advise every young man—yes, every middle-aged man—to acquire all the education, especially technical education, that he possibly can, and never to give up until he has secured it.

"I would urge men, in order to secure the confidence of employers and advancement to positions of trust, always to be truthful, no matter what it may involve. The loss of position is nothing compared with the loss of an employer's confidence. I have several times risked my position on the truth, and I never lost. Stand up to all the dignity of your manhood, look every man straight in the eye, and speak fearlessly the truth and nothing but the truth."

A GREAT ERA FOR YOUNG MEN

The young man of today is in great demand. He is sought for by the managements of all kinds of business. Every large business house has positions waiting for the young men who can satisfactorily fill them. The demand for properly qualified young men, at present, is far in excess of the supply.

A New York business man stated last year that he had made a personal canvass of a dozen of the largest business houses in five different commercial and professional lines, to see to what extent openings existed for young men. In only two of them were the managers satisfied that the responsible positions were occupied by capable men. Even in these two houses he was assured that "Of course, if the right sort of a young man came along who could tell us something about our business we did not already know, we should not let him slip through our fingers, but would create a position for him." In several of these houses, positions had been open for many months, in spite of a sharp lookout for suitable candidates. Every one of these firms had positions paying from $2,000 to $5,000 a year, simply yearning for capable young men to fill them. It is safe to estimate that there are in New York alone over five thousand openings of this class.

It is no question of salary with these great firms; it is a question of the highest skill combined with perfect reliability. There is almost no limit to the salaries that will be cheerfully paid to the right men.

One immense business concern, doing such a vast business as to be classed as a "trust," is experiencing the greatest embarrassment because of the absolute lack, at this time, of technically educated men. Last June this concern found it necessary for its welfare to employ a dozen or more young men fitted for its work by technical education. Good salaries—very large for beginners—were offered to make certain that the positions should be filled promptly. In addition, the attractiveness of the vacancies was much enhanced by the fact that those who should fill them would be rapidly qualified to become technical experts, capable of earning large salaries and possessed of brilliant futures.

It was decided to request the leading technical schools to recommend recent or prospective graduates. In response to this request, sent to the Massachusetts Institute of Technology, it was learned that all the graduates had already secured good positions, and that all Boston was unable to furnish even one young man capable of filling a desirable place in a great industry in New York. Similar inquiries sent to Stevens Institute, at Hoboken, New Jersey, the University of Nebraska, Rensselaer Polytechnic Institute, at Troy, New York, Cornell University, and several others, developed the remarkable situation that every technically

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educated graduate capable of filling such a position had secured work within a week after graduation, at a good salary. It has thus far been found impossible to find among the young men of the United States any competent to do the technical work required, who are not now in full employment, finding elsewhere salaries and opportunities for advancement equal to those which they would have had in this New York office. It is probable that this great industry will have to wait until another class is graduated from the schools of technology, before it can satisfactorily fill its dozen or more desirable openings.

One of the subordinate officers of a large New York corporation recently resigned a position at a good salary to accept one of much greater promise. It was decided to fill his place with a young man who had some training for the business. There were many found who were competent, but it took a two months' search to find a young man whom they could persuade to take the place, even though its prospects would satisfy almost any person.

The head of a great department store stated a month ago that, in all his life as a business man, he had never known finer openings for ambitious young men who had industry and were of good habits, especially when they added to these qualities the important one of ability.

"Capacity was never more speedily allotted to its appropriate place," says another prominent business man, "or receiving better pecuniary returns than is the case today. Our great corporations and industries are constantly upon the lookout for young men of ability; and advancement in these industries was never surer or better paid than now."

President Vreeland, the newly chosen chief of one of the vast street-railway systems of New York, who in a few years has risen from the position of brakeman, says that he is "more and more persuaded that the opportunities which await every young man are only to be measured by his capacity and industry." In his opinion we are at the opening of an era when the greatest of all opportunities await young men.

No long explanation is required to tell young men what to do to prepare themselves for these great opportunities. It is a foregone conclusion that all of these great openings will be filled by the young men of today who are striving to develop themselves along the two lines of character and technical education.

Integrity is absolutely demanded as the foundation of advancement. Added to integrity must be manliness, self-reliance, concentration, unflinching determination, and enthusiasm and energy based on good health. Another chief essential is hard work, welcoming any pains whatever.

Above all, the young man who desires to be equal to his opportunities must possess or acquire a good technical education—a thorough working knowledge of the principles underlying his chosen line of work—such as can be obtained either in the schools of technology or in the engineering and industrial courses of a first-class correspondence school.

STEPHEN GIRARD'S "SUGGESTIONS"

Not the least part, doubtless, of the success that attends the graduates of Girard College, Philadelphia, is due to the example of success set them by its founder. In place of false standards of success, the following wise "suggestions" are placed in their hands, as the fruit of the experience of Stephen Girard, the millionaire philanthropist:

1. Be punctual. Never be a minute late in arriving at your place of business, but often five or ten minutes early.

2. Make your employer's interest your interest. Aim to do your tasks in the best manner possible. Be sure that you understand your employer's wishes, and then do your best to comply with them.

3. Do your work cheerfully. A cheerful spirit and agreeable manners please not only your employers, but all with whom you have occasion to associate.

4. Do your work promptly. Get through with as much work as possible in the early part of the day. Always see that half an hour's work is done in half an hour.

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5. Do not be disheartened at difficulties. It is not likely that you will at first be entirely pleased with any position. All beginnings are difficult. Give the place a trial of one month at least before you decide against it; and however much you may dislike your employment, let not your dislike show itself in indifference or inattention to your duties.

6. Be not given to much talking. Do not discuss your own affairs or your family affairs with strangers. Never criticise your employers or your associates.

7. When your own special task for any day is light and not sufficient to keep you busy, do not fail to offer your assistance to others. This will serve to create a friendly feeling between you and your associates.

8. This is a busy age. Everybody is hurrying. Much is done in a short time. Therefore move briskly and step lively if you hope to meet the expectations and approval of your employers.

9. There will be times when you will need to remain on duty after regular hours. Do not murmur or show any displeasure on such occasions. Accept the situation bravely, and work with increased earnestness.

10. Always keep in mind self-improvement. Learn wherever and whenever you can. Make yourself worthy of promotion by the manner you improve in your work. One way to improve yourself is to study carefully the methods and habits of the successful business men whom you see and meet.

11. Improve your leisure hours by careful reading. In order to command respect, a young man must know something of the world and its daily life, its public affairs, and its public men. To be able to converse intelligently, you must read not only the daily papers, but also good literature.

12. Be scrupulously honest in all you do, and truthful in all you say. Prize a noble character above everything else, and let no one ever tempt you to do a mean act.

STEPPING STONES TO SUCCESS

Not all failures are calamities. Mishaps, like knives, either serve us or cut us, as we grasp them by the handle or the blade. A downfall is often an uplift. There are beneficial and promising defeats, as there are inglorious and disastrous victories.

It does not at all follow that because a man has failed in one thing, or several things, he cannot and will not succeed in something else. Story and history are full of the examples of men who made their mark after an utter failure in their first attempts.

Jay Gould, the great railroad financier, made a complete failure as a shopkeeper, tanner, a surveyor, and a civil engineer. P. T. Barnum, the world's greatest showman, failed in fourteen different occupations before finding his forte. Phillips Brooks, the pulpit orator of New England, failed as a school teacher, and went into the ministry against the solemn warnings of trusted and influential friends, but with the determination to do his best. Alexander Wilson, the Scottish ornithologist, made a failure of five different professions before finding his place. These men, and thousands of others, made each failure a stepping stone to success.

Some of the most extraordinary examples of pluck under disheartening circumstances, says the Saturday Evening Post, have been furnished by military commanders. Napoleon said of one of his marshals, Massena, that "He was not himself until the battle began to go against him; then, when the dead fell in ranks about him, were awakened his powers of combination, and he put on terror and victory as a robe." Blücher, the obstinate old Prussian general, lost nine battles out of ten, but quickly rallied and showed Napoleon after every defeat a more formidable front than before. Defeated, wounded, and unhorsed at Ligny, he led his troops two days later, amid torrents of rain, through deep mud, up steep defiles, from Wavre to Waterloo, and won with Wellington the immortal victory that sealed the fate of his foe.

The epitaph carved on the monument of a famous man—"Here lies one who meant well, failed much, tried a little"—is one of which no one need be ashamed. In one's strivings for advancement it must be remembered that:

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Heaven is not reached by a single bound,
But we build the ladder by which we rise
From the lowly earth to the vaulted skies,
And we mount to the summit round by round.
We rise by the things that are under our feet.

Perhaps we have won when we seem to have lost. A true gain is very often the result of an apparent loss. We strive; we fail. Strength was gained by the striving; and if we knew the end from the beginning, we would be profoundly thankful that we failed.

The victory which slackens and enervates, which unknits the sinews of the will and quenches the thirst of aspiration, is in truth a deplorable defeat. That defeat which braces the energies and quickens new powers of thought, resolve, and effort is a virtual victory. The unaccepted defeats of the man, who by indomitable prowess has advanced "inch by painful inch," are turned to triumphs.

We never truly fail until we completely give up and lay our purpose in the dust. "Man does not yield himself to the angels, nor even unto death," says Henry Sabin, "save through the weakness of his own feeble will."

The temporary result is less important than later consequences. What growth has been gained through the effort? That alone is of real moment. What is carried forward in the form of new strength, of liberated, reinforced power, and enlarged purpose—that is the vital point. Is the victory an outcome and a condition of growth, valued not for the prize but for the opportunity? Then all is well. Does it bring content, arrested effort, sloth, in its train? Then all is ill. The true victory is but an episode in a greatly planned, life-long campaign against the obstacles that hinder a man's development; it is a means to a remoter end as well as an end for the time being. The successful man is the one who studies his failures and makes their lessons stepping stones to the complete accomplishment of his ambition.

EDUCATION AND SUCCESS IN LIFE

In every line of work it is the man who knows most about what he is doing, other things being equal, that comes out ahead.

Education invariably pays. If a man desires to forge ahead, the surest means he can adopt to help himself is not money, nor influence, nor any of a hundred outside aids, but a good education. If he cannot go to college, a course by correspondence, combined with experience gained in daily work, will enable him to do as well in the long run as if he had taken a resident course of study. Nothing can keep a determined man from going to the front.

The following remarks by President Benjamin Ide Wheeler about thorough students at college, applies with equal force to correspondence students who study hard at home.

"There are individual cases, as every one knows, of success from the lowest third of the class, and the comment of surprise gives them luster. I believe they are comets, however. In my observation, the successful men come chiefly from the first third. When the high scholar turns out a commonplace man, the dunces have their delight, and the one exception outweighs five illustrations of the rule.

"A college man wins in life not by virtue of the special knowledge he has acquired so much as by the habits he has formed. Habits of mind involve an attitude toward truth. Habits of thinking involve a control of the mental processes. Habits of work involve sense of time and for duty. A man who does things at the time when they ought to be done is likely to be wanted. It is the men who are wanted who are the successes. The men who are forever toiling to create a demand for themselves, they are the nuisances. The best scholars succeed best in life chiefly, I believe, because they have been most regular and punctual in doing their college work. My experience with college students teaches me that they are intellectually much nearer a level than their achievements indicate. It is power of will more than power of mind that differentiates them. Must and ought have fifty times more stuff in them than might and could. I have known men of the most superb equipment and the finest intellectual and athletic training who were of no possible use for any other sublunar purpose, because they could not be relied upon to keep an appointment or to do anything."

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PREPARE FOR OPPORTUNITY

For every man and woman in this free land comes at some time in life a crisis as acute and as significant as that which, in 1776, confronted the Continental Congress. They have to consider whether they shall be free and independent. What shall the answer be? Shall they be slaves to circumstances, or seekers after true success?

Soul of mine,
Wouldst thou choose for life a motto half divine?
Let this be your guard and guide
Through the future reaching wide,
Whether good or ill betide—
Rise higher.

"O friend," well exclaims Emerson, "O friend, never strike sail to fear. Come into port grandly, or sail with God the seas!"

"What's brave, what's noble, let's do it," says Shakespeare, "after the high Roman fashion, and make death proud to take us."

No higher deed is done than by him who devotes nights to study after days of toil. It is a great thing, well worth sacrifice of pleasure and leisure moments, for a man to make himself a better and more useful man. The world appreciates such spirits. Not only does self-improvement lead to better position and more remunerative work, but to a higher place in the esteem of the community.

Every man wishes to be well thought of. Many of us willingly endure all adversities of fortune to keep our good name and the respect of our fellows. How well worth the effort of solitary study it is to have the feeling of mastery.

To students of our Schools we say: let nothing hinder your progress. Present difficulties and discouragements and the temporary sacrifice of a little ease will seem as nothing a few short years hence, when you shall have gained that for which you are striving. In no way can you show your manhood as well as by a determined and sustained effort *now* to prepare yourself for the very best future of which you are capable.

FIDELITY IS IRRESISTIBLE

Some power making toward success that would be resistless—who, in all this power-thirsty race, would not eagerly cry out to possess such a gift? "It is talent," says one of the world's wise men. "It is genius," asserts another, "combined with favorable circumstances." No, it is faithfulness in little things.

So simple a thing as fidelity in little things is resistless. Find a carpenter who is absolutely faithful in every detail of his work, and you may guarantee his success. Point to a clerk with a conscience that will not permit him to shirk the most trifling minutiæ of his assigned duties, and you may promise him a choice of the best clerkships in his town. Discover a professional man who no more fails to be faithful in trifling details than he does in the great things, and you may write him offhand an assurance of success. "Genius is patience," said Buffon. "If I differ from other men at all, it is in patient thinking," said the great Newton. "The men who have most moved the world have not been the so-called brilliant men, but the untiring workers," writes one. "How long will it take to learn to play the violin?" asked a young man of the great violinist Giardini. "Twelve hours a day for twenty years together," was his reply.

Greatness in any direction is an accumulation of little faithfulnesses towering into sight of the world. Real accomplishment in any line comes, as the coral reefs are built, by the deposit of one tiny cell of fidelity to duty upon another, till thousands of unnoticed fidelities loom into visible greatness. An isolated instance of devotion to duty is like a single drop of rain. Days full of such stern fidelities are like a fall of rain bringing the life to flower and to fruitage.

It is not difficult for us to see that in business or in the professions spasmodic performances of duty are not likely to lead to success. Running a life by jerks of effort is a good deal like running a railway engine on a track in which some of the rails are missing here and there.

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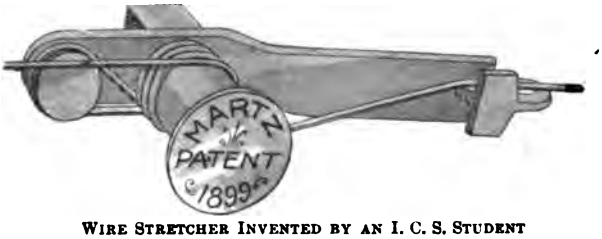
It is all right where the track is good, but destructive accidents will be in evidence where the rails are wanting. The call to be ruler over many things in the business and professional world must surely come to the one who is faithful over a few things.

A STUDENT'S INVENTION

The accompanying wire stretcher is the invention of Mr. R. N. Martz, of Frederick, Md., who is taking the Electric Power and Lighting Course. This device is intended to take the slack out of wire fences, telegraph and telephone wires, guy wires, clothes lines, and all wires that need to be kept at a tension. It is probably the cheapest, simplest, neatest, and most durable and quickly adjusted article of the kind. It is operated by placing the wire between the two pins with one wrap on the short pin, then continuing to wrap around the long pin by turning the implement, and locking the wire with the long arm on either half turn.



WIRE STRETCHER INVENTED BY AN I. C. S. STUDENT

Mr. Martz is also the inventor of a device for fastening wood, steel, or twisted-wire pickets to wire fences, and is working on some electrical appliances which he hopes soon to have on the market.

Speaking of his Course of study, he says that it has brightened his ideas and aided him wonderfully in proportioning, designing, and proof pattern work.

A COLLEGE PRESIDENT'S ADVICE

"Young men," said President Porter of Yale to the students of that institution, "you are the architects of your own fortunes. Rely on your own strength of body and soul. Take for your star, self-reliance. Inscribe on your banner, 'Luck is a fool; pluck is a hero.' Don't take too much advice—keep at your helm and steer your own ship, and remember that the great art of commanding is to take a fair share of the work. Think well of yourself. Strike out. Assume your own position. Put potatoes in a cart over a rough road, and the small ones go to the bottom. Rise above the envious and jealous. Fire above the mark you intend to hit. Energy, invincible determination, with a right motive, are the levers that move the world. Don't drink. Don't smoke. Don't chew. Don't swear. Don't deceive. Be in earnest. Be self-reliant. Be generous. Be civil. Make money and do good with it. Love your God and fellow men. Love truth and virtue. Love your country and obey its laws."

HASTE

The passage of centuries has not changed the opinion of the wise regarding the folly of haste. "Haste," said Seneca, the Roman philosopher, two thousand years ago, "trips up its own heels, fetters and stops itself." Sir Francis Bacon, speaking on the same subject, fifteen hundred years later, related the incident that "Sir Amyas Pawlet, when he saw too much haste made in any matter, was accustomed to say, 'stay awhile, that we may make an end the sooner.'" The present century adds its testimony also. "Hurry and cunning," writes Walter Colton, an eminent American writer, "are the two apprentices of dispatch and skill; but neither of them ever learns his master's trade."

PERSONALITY AND SUCCESS

What a man is, mainly settles the question of what he can do. Both his deeds and his words take their power from his personality. A man's example gives added weight to his testimony in favor of what he advocates, but his character is felt through all that he says or does. That which has a controlling power over him is sure to be felt as a power by those who observe him. It has been well said that "a man's character will be the limit of his personal influence in the direction of such attainment."

"Every great and commanding movement in the annals of the world," says Ralph Waldo Emerson, "is the triumph of enthusiasm."

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ASSISTED TO GOOD POSITIONS

The recommendations of the Students' Aid Department are a strong incentive to make progress in our Courses. Any student is entitled to the assistance of the Department as soon as he has completed one division of a Course. On application to the Schools, this Department will then advise his employer, from time to time, of his increasing educational qualifications for responsible work. For students who wish to obtain other positions, the Students' Aid Department will write letters of recommendation stating what subjects they have completed.

It is important for students who utilize this help to advance as rapidly as possible in their studies. It is of equal importance for them to do conscientious work—to master each subject thoroughly. Otherwise they will not be as well able as they ought to apply their knowledge to their work.

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Many of our students obtain good positions, partly, at least, on account of the recommendations of the Students' Aid Department. As an incentive to others to advance and excel in their studies, we instance a few typical cases from the list of those who have recently done so:

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Foreman.—E. S. Crane, Complete Mechanical Course, with the Acorn Brass Works, of Chicago, Ill.

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Foreman Blacksmith.—W. J. Frost, Complete Mechanical Course, with the Equitable Auto-Truck and Power Co., Boston, Mass.

STICKING TO IT

Few men owed more to perseverance than Dr. Samuel Johnson, whose untiring efforts gave the English nation one of its best dictionaries, as well as much of the finest thought in all literature. Like all earnest workers, he found pleasure in persistent work. "Life affords no higher pleasure," says he, "than that of surmounting difficulties, passing from one step of success to another, forming new wishes and seeing them gratified. He that labors in any great or laudable undertaking has his fatigues first supported by hope and afterwards rewarded by joy." The sooner a man realizes the truth of this principle and begins to apply himself to enthusiastic, hard, and perfectly honest work, the sooner he will achieve the goal of happiness, and later on that of success.

THE CHEAP MAN

The man who is content to fill a position in life which requires no preparation, no study, no training, must be content as well with the wages of a menial. To secure the richer and lasting rewards of life, character, mind, money, or position, the man must pay the price of severe training and thorough preparation, though it cost years and much money.

"Did you ever hear of a man," remarks Thoreau, the hermit philosopher of Concord, "who had striven all his life faithfully and singly towards an object, and in no measure obtained it? If a man aspires, is he not elevated? Did ever a man try heroism, magnanimity, truth, sincerity, and find that there was no advantage in them—that it was a vain endeavor?"

True courage is like a kite: a contrary wind raises it higher.—*J. Petit Senn.*

"A bold onset is half the battle."—*Garabaldi.*

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GROCERY CLERK TO COLLEGE PRESIDENT

JACOB GOULD SCHURMAN, PRESIDENT OF CORNELL UNIVERSITY

Jacob Gould Schurman, Chairman of the recent Philippine Islands' Commission, is one more distinguished citizen who has, by force of merit, achieved distinction in the United States.

He was born in Prince Edward Island, fifty-four years ago, and the earlier years of his life were all spent on Canadian soil.

Mr. Schurman's father was a New Yorker. He had moved to Prince Edward Island in 1840, cleared a little land and built himself a house. He was poor and there were eight children to support. Jacob, who was the fourth child, spent his earlier years doing what he could to help with the work and attended district school, miles away, in all kinds of weather. At thirteen he left home to make his way in the world, and from that time on he never received a penny that he did not earn.

JACOB GOULD SCHURMAN

For three years young Schurman worked in a country grocery in a little island town, receiving $30 a year and his board. Then he decided that he wanted a better education, and started out to get it. By working for his board he gave himself a year's schooling. He had never before studied Latin or Greek, but in that year he got the preparation for college which costs an ordinary boy four years' time. He won a scholarship in Prince of Wales College, Charlottetown.

With a few dollars which this scholarship yielded, and what he could earn by keeping books and tending store in the evening, he paid his way for two years. At the end of that time he graduated from the college at the head of his class.

Schurman went to Acadia College, in Nova Scotia, to continue his education. At the end of his course a scholarship in the University of London was offered for competition in Canada. Schurman went into the examination and won the prize.

In London Schurman took up the study of philosophy. In three years he won his doctorate. He wanted to go to Germany and study under the great leaders of philosophic thought. The Hibbard Society, in London, offered a traveling fellowship to encourage the independent study of philosophy. It paid $2,000 for a year, and the holder could pursue his studies whenever he chose. It was open to all graduates of the Universities of Great Britain and Ireland.

There were over sixty competitors, the star men of Oxford, Cambridge, Edinburgh, Aberdeen, Dublin, and other famous universities. The boy whose earliest school had been the backwoods farm in Prince Edward Island, stood above them all at the end of the competition.

At the end of his stay in Germany he went back to Acadia College and accepted a professorship. But he did not stay long. Professor Schurman was a man of independent thought, and some of his ideas did not meet favor in the institution, where the principal work was the training of men for the Baptist ministry. He resigned, and was almost immediately called to the chair of philosophy in Dalhousie University, at Halifax.

Through Professor Schurman's going to Dalhousie he met Miss Munro, the young woman who became his wife. Her father, the pub-

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THE INTERNATIONAL CORRESPONDENCE SCHOOLS, SCRANTON, PA.

lisher, George Munro, of New York, was the principal patron of the institution of Halifax, to which he gave a large part of his fortune.

In 1886 a chair of philosophy was established in Cornell. President Andrew D. White recalled the brilliant young Canadian he had met at one of his receptions while Minister at Berlin, and whose book "Belief in God" he had read. He sent for Professor Schurman, and the Canadian scholar became connected with Cornell.

At the time when Dr. White sent for Schurman, the latter was preparing to go to Ottawa in answer to a summons from Sir John Macdonald. The astute Conservative leader had heard of the young college professor, and urged him to enter Canadian politics. But Dr. Schurman preferred to continue in the scholarly way.

In Cornell Schurman was fortunate in forming a close friendship with the late Henry W. Sage. Under his influence Mr. Sage was induced to found the School of Philosophy, now the most important in the country.

When Charles Kendall Adams resigned the Presidency of Cornell, in 1892, Dr. Schurman was elected to fill his place.

Although one of the youngest college presidents, Dr. Schurman has been one of the most successful. Under his direction Cornell has grown rapidly in wealth and attendance. He is popular. No leathern-lunged sophomore rejoices more when Cornell wins a boat race than does the President.

Dr. Schurman is a man of magnificent physique, with a strong, intellectual face and easy and pleasant manners. He takes a great interest in all young men, especially those who, like himself, have their own way to make in the world.

President Schurman is the senior editor of The Philosophical Review, the leading journal of general philosophy in America. He has helped to give this publication an exceedingly high tone. He is a frequent contributor to philosophical reviews, educational journals, The Forum, etc. He has written and published several noteworthy books, among them being "Kantian Ethics and the Ethics of Evolution," "The Ethical Import of Darwinism," "Belief in God," and "Agnosticism and Religion." President Schurman took an A. M. degree at the University of London, D. Sc., at the University of Edinburgh—both in course—and he has received the honorary degree of LL. D. from Columbia University.

"PUT DOWN MY NAME"

Choose a career, and labor on it undismayed, unflinchingly, says the Educational Independent, and success comes—or rather you will come to it. Nothing illustrates this truth better than the life of the famous explorer, Dr. Heinrich Schliemann.

Years ago a German father read to his boy a translation of Homer's story of the siege of Troy, and the lad made up his mind to find the ruins of that ancient city. Troy had perished in flames three thousand years ago—if, indeed, it ever existed at all. "But," said the little German, "I will find it."

Though a poor lad, slaving at work until bedtime, he procured books and taught himself six or seven languages. He pushed on and prospered until, as a merchant, he had made a fortune. Every step of his study and money-making was taken with the specific aim of fulfilling the vow of his boyhood. In due time he started to Asia Minor with a company of laborers, and for long, long years pursued his search. At last success crowned his efforts—he found Troy. His discovery created a sensation through all the world. It is now but a short time since the treasures of gold, silver, and bronze dug out of the palace of the king of Troy, were exhibited in London.

For three thousand years the blackened ruins of that famous city had lain covered with sand. By many the city was regarded only as the fabled creation of poetry, but this German lad, at his own unstinted expense and by his amazing enterprise, proved the discovery to the world.

Think upon it. A poor boy, learning languages at home, making a fortune, spending seven years in far-away deserts, sustained through a life-time by one fixed resolution. He vowed in boyhood that he would find Troy, and he did find it. As a mere boy he said, "Put down my name," and when life was far spent he succeeded in winning his way into the world's Temple of Fame.

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A LARGE STUDENTS' CLUB

From widely separated parts of the country come reports of prosperous organizations of correspondence students in industrial plants. A very successful club has been running for many months among the employees of the National Cash Register Company, at Dayton, Ohio.

Joseph D. Welden, chief engineer of the Danville, Pennsylvania, Bessemer Company, formed a club of sixteen young men from different departments of the works. The members are studying different subjects, but they find it profitable to meet together and help one another on the road to self-improvement and success. Speaking of his reasons for organizing the club, Mr. Welden stated that "It lies principally in the desire to have men about us in the works who are likely to be of future use in furnishing available men for advanced positions as they come up. I have found it pays far better to take young men from lower positions and break them in on special work than to hire outsiders."

MANAGER'S OFFICE, DRAWING ROOM, AND STUDENTS' CLUB AT ADDYSTON, OHIO

The subject of the illustrations given with this article is the large club of I. C. S. students in the works of the United States Cast Iron Pipe and Foundry Company, at Addyston, Ohio, one of the largest establishments of its kind in the country.

The fact had long been recognized by the assistant superintendent, Mr. Andrew Scheifer, that he could save from three to four hundred dollars a month, in the foundry and machine shops, by having his men familiar enough with mechanical drawing to readily read the drawings set before them. He said he would be well satisfied with that much, even if the men did not all become skilled draftsmen. With this end in view, he started a drawing class of forty-one men from all departments of the works.

The Addyston class is now under the patronage of the general manager, Mr. McLaren, Mr. Scheifer having recently been made superintendent of the Bessemer, Alabama, branch of the company, where he is organizing another class of students. Mr. McLaren takes great interest in the work of the men in their drawing room. He says that he sees plainly where the company will be greatly benefited by this study on the part of the men.

Every effort is made to give the student-employes proper facilities for pursuing their studies. A fully equipped drawing room much better than is furnished by many concerns for their expert draftsmen, has been fitted up for their use.

Corporations that encourage and assist these students' clubs have solved the problem of how to get trustworthy and thoroughly competent men to take the vacant places that occur from time to time in all big establishments. They are assured of having men in their employ, at all times, upon whose knowledge, technical as well as practical, they can rely. Many firms do not approve of discharging old hands, even where it is apparent that they are not up to the standard of modern workmanship; and the student-club method of bringing them up to a high standard furnishes an easy solution of the problem to the executive officers of large corporations, whose greatest difficulty is to secure the best qualified workmen and heads of departments.

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PRACTICE, THEORY, AND HYPOTHESIS

An educated man is recognized, not by the size of the words he uses, but by his exact use of words. Accuracy of language, whether written or spoken, is essential to success. Its careless, slovenly, inexact use gives an impression of carelessness in other things.

Few words are used oftener or more vaguely than the word "theory." To this term is very generally attributed a quite erroneous meaning. It is usually confounded with the word "hypothesis" and used where the latter word would convey the meaning intended.

When a thing has been done or observed so often that general rules concerning it have been found to be true, these general laws constitute theory. Theory is based on experience. It is practice written down. In any particular line, it is a statement of the experience of those engaged in that business.

Any supposition, whether probable or not, that is not founded on facts determined by experience, is an hypothesis. A schoolboy's idea about the world and its strenuous life is his hypothesis concerning it. A man who is not familiar with a business could not be said to present a theory about it, but only an hypothesis, or supposition. Detectives in following up a clue, act on an hypothesis, because their ideas are not statements of proven facts but of suppositions thought out in their minds.

Suppositions are sometimes afterwards proved to be in accordance with facts. An hypothesis may thus, by comparison with the results of experience, be shown to be true. It then becomes theory, but not until its truth is established by facts derived from successful practice.

Theory is determined by experiment, observation, and thought. Not the simplest work can be done without theory. You send for a mechanic to do some work about your house. Suppose he works by hypothesis only. He pulls down your walls, tears up your floors, and finds at last that he has done it for nothing —ought to have done something else. Another man comes who works according to established theory, and before doing anything, stops and thinks. He looks and then reflects. He tries an experiment carefully, and watches the result. At last he finds the cause of the difficulty and immediately proceeds to remove it. Every step he takes is done according to theory established by experiment or by previous experience. His knowledge of theory has saved you money and gained him the reputation of a reliable and progressive workman.

"I sometimes pass a sign," says James Freeman Clarke, the well-known American writer, "on which the artisan has painted, 'John Smith, Practical Plumber.' I should not wish to employ him. When the plumbing in my house gets out of order, I want a theoretical plumber as well as one who is practical. I want a man who understands the theory of all the sciences of hydrostatics, the qualities of materials, and the other things that relate to his trade; and this a merely practical man cannot do. The merest artisan needs to theorize —to *think*—to think beforehand, to foresee; and it must be done by the aid of general principles, by the knowledge of laws. All success depends on practice, but all improvement on theory. Let neither despise the other."

In working according to theory a man is merely following the methods of the best and greatest in his line. He applies the methods that have been proved best for each case. Knowledge of this kind must be at the ready command of any mechanic who desires to rise to a position of responsibility.

This knowledge is especially necessary in the use of modern machinery. A certain woodworking factory which is well equipped with the very latest machinery, has, however, a superintendent of the kind who does not need to be told anything and yet never rises above a very small salary. Not one solitary machine in his shop was running at anywhere near the right speed—most of them either half too slow or too fast. In response to a suggestion to figure the peripheral speed of his machines and make proper allowances for hard and soft wood, the superintendent, a "practical" man, said, "Out with your peripheries and high falutin' talk! I'm running my machines according to common sense, and the faster they run the faster they will cut." He was, as a matter of fact, wasting half the time of the machinery sharpening and repairing cutting parts, and it was only after an actual demonstration of the effectiveness of

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the theoretically correct speed, that he permitted the speed of the machines to be altered.

Such is the "practical" man. He does not realize, what is apparent to all who know, that he is the least practical of men. He does not know that theory and practice go together, because one is derived from the other.

Hypothesis without practice to test it, to verify it, to correct it is idle speculation; but practice without theory is energy misapplied.

To say that anything is "True in theory but false in practice" is a misuse of terms. An hypothesis may be plausible, but false; but theory is the result of practice and is true necessarily.

Men working side by side do a certain amount of labor—one with far less exertion than the other. One is familiar with the theory of mechanical practice, and calls it to his assistance. The man with more knowledge, not the one with more strength, is the profitable workman. He is equipped with a knowledge of laws not to be acquired in daily routine, but nevertheless essential to his success, a knowledge that cannot be obtained without study of what others have done and learned. One of the secrets of success is not the mere possession of power, but the knowledge of how to apply it.

SELF-IMPROVEMENT REQUIRES PERSEVERANCE

"Many, when circumstances have turned their attention to self-improvement, and while the glowing picture is before them," says Tryon Edwards, "often make excellent and sometimes prodigious resolutions. But because they do not at once, as by a leap, become perfect, they are soon ready to give up their efforts in despair. For such, for all, it were well to remember that self-education is a matter of slow progress, of patient and persevering effort, and that in little things, from day to day and from hour to hour.

"It is the fixed law of the universe that little things are ever the elements—the parts—of the great. The grass does not spring up full grown; it rises by an increase so noiseless and gentle as not to disturb an angel's ear, and not to be seen by an angel's eye. The rain does not fall in masses, but in drops, or even in the breath-like moisture of the fine mist, as if the world were one vast condenser, and the Almighty had breathed upon it. The planets do not leap from end to end of their orbits; but in their ever onward progress, inch by inch, and line by line it is that they circle the heavens.

"And so with self-improvement. It is not a thing of fits and impulses, and explosions, but of constant watchfulness, and patient and unwearied effort, and of gradual and ceaseless advancement.

"Like the wealth of the miser, it must be heaped up piece by piece; and then, at length, like the wealth of the miser it may also be without limit. Like the coral reefs of the ocean it must grow by small but constant additions; and then it will finally be like those coral reefs, admirable in all its parts, and rivaling the very mountains in size."

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TAKING STOCK

It is a good idea for those on the pathway of self-improvement to stop occasionally and take stock of progress.

A mental and moral inventory will show exactly where you are, and if you have been practicing self-help for many months, you will be surprised at the advance made in many lines.

In a financial way, the expense of your course of study may easily have been offset by money saved from evenings spent at home and not "out with the boys." You cannot, moreover, conscientiously follow up a course of study without being stimulated, through increased mental efficiency, to greater efficiency in daily work. If you have not already experienced an advance in position or salary, you can be sure that it is only because you have not been at it long enough, or a good chance for you to seize has not presented itself. Your superior officer has been watching you, however, and if your endeavors for self-improvement have been earnest and sincere, you have risen in his estimation and are that much farther along than when you started.

The retrospect over the year's efforts at self-improvement will show a decided balance on the side of increased mental power. The gray matter of the brain grows in strength and quality through mental exercise, just as surely as the muscles of the body do through athletics or manual labor. If you have persevered in a course of study in the months just past, you can be certain that your increased mental alertness and power of concentration constitute no small addition to capital that will tell heavily in future progress.

Did you ever think how much of an uplift a course of study can be in a social way? Do you know what is the heart and soul of all the good society in the world? All the society that is worth anything at all is founded on the superior aims and thoughts of its members. Money is not the basis of good society—brains and character are. Your course of study has substituted for you higher thoughts and aims than you had before, and in proportion as you have gone into it with thoroughness and enthusiasm, it has lifted you into the company of the world's best and greatest, made you the same in spirit as the members of the best society, and raised you high in the esteem of those of your associates whose good-will is worth having.

All told, the retrospect over the past should give you both much cause for satisfaction, and some regrets doubtless, that in some lines more progress has not been made.

After the inventory is taken, and all the stock accounted for, good and bad, comes the time to lay plans for the affairs of the coming year.

Brains and character constitute your capital, and self-improvement the method for advancing your interests.

You have made progress in the year just past. Resolve to have even greater financial, mental, and social assets when you next stop for inventory.

Have you, in any respects, failed to make an advance? In some department your stock is stationary or shows a loss? Make careful note of every point that does not show advancement, and resolutely plan for special attention to all weak points in the development of mind or character.

To be certain of substantial progress the coming year, you must devote as careful attention to every phase of self-improvement as a merchant does to the development of his business.

The New Year, from time immemorial, has been the turning point of many a life devoted to self-help.

The ancient Romans always did something in the way of their art or calling, to begin the year industriously, counting it lucky to begin any new enterprise or enter upon any new office on New Year's Day. Every day that is given to elevation of mind or character, is, of course, a day of good fortune. But the beginning of the new year will always appeal to many as an appropriate time to "turn over a new leaf."

If no progress has been made in the past twelve-month, see to it now that you do not have the same regret to feel a year hence; and in all lines in which you have advanced, resolve that at the next stock-taking you will be able to look back upon an even greater growth than you can today.

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CLERK TO GENERAL MANAGER

H. F. MacGregor, Vice-President and General Manager of the Houston Street Railway Company

"Average ability, honesty, and good habits," says H. F. MacGregor, vice-president and general manager of the Houston (Texas) Electric Street Railway Company, "are the three underlying conditions for success. In addition to these, a man should be industrious, and should endeavor to acquire sufficient knowledge of the business he is engaged in to operate it, and to conform to the views of his superior in his absence, so that his employer will feel perfectly safe in leaving any part of the business, or all of it, in his hands to direct.

H. F. MacGregor

"Successful business men like to lean on competent men and to be relieved of the onerous work which competition has forced on them.

"Those that have shown a capacity to make money for other people will find it easy to obtain money belonging to other people, with which to go into business on their own account, even if their own savings have been small.

"The executive quality is what commands large salaries, and financial backing when needed. Mere clerical work and perfunctory service, even of the highest class, does not attract attention and is very easily obtained, because plentiful. Any man who will study to grasp the whole situation and will undertake to improve his opportunities fully in an executive way will attract attention. I do not mean by this that a man should undertake to demonstrate that he knows more than the man who is employing him, but that he should endeavor to carry out the views of his employer; if he has suggestions of merit to make, they will be gradually adopted, without his trying to be too smart. The cause of failure of some men of ability is that they expect their views to be adopted at once, and think their education is superior to that of the man they are working for. They make an untactful display of this, instead of working patiently and performing their duties in a way that will commend itself and bring a profit to the business. They should be satisfied with a gradual process of promotion.

"Success comes only after a long period and a great deal of hard work. There is no easy way to fame or fortune."

Mr. MacGregor was born in Londonderry, New Hampshire, of Scotch-Irish descent, his people being among the first settlers of that state. He went through the usual course of New England boys, working on the farm in summer and going to school in winter. After graduating from the New Hampshire Business College, he clerked for two years in Massachusetts, and at the age of eighteen came to Texas and immediately found employment in the Galveston office of the Houston Direct Navigation Company.

After the steamboat business was crowded out by the railroads, he was elected secretary of the Galveston City Railroad Company. He became interested, later, in the Houston City Railway Company, and is now vice-president and general manager of its successor, the Houston Electric Street Railway Company. Mr. MacGregor's prominence in business affairs is also shown by the fact that he is president of the Houston Business League, third vice-president of the South Texas National Bank, treasurer of the Houston Printing Company, publishers of the Houston Post, and has other business connections. In politics, also, he has risen to much prominence, having been chosen president of the Republican State League of Texas. His busy and successful career constitutes an excellent example of what any young man can accomplish by hard work and the persistent cultivation of the qualities universally known to make for success in life.

"The great high road of human welfare lies along the old highway of steadfast well-doing"; says Samuel Smiles, "and they who are the most persistent, and work in the true spirit, will invariably be the most successful. Success treads on the heels of every right effort."

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You could waste half your lifetime experimenting on methods that others have long since found bad—something you might have found in a single day, by reading what they have discovered about it.

You will never be paid for how much you do, nor for how long a time you spend at your work. "Your work may occupy long hours," says Edward Atkinson, "and may be applied to arduous manual labor, or it may be done in a short number of hours per day, with but little physical effort. Neither the hours nor the effort constitute any measure on which payment can be based. The measure of payment is fixed by the measure of the work saved to him who makes the payment."

To save your employer labor, you must study his business in all its aspects, practical and theoretical. You must think, think, think, about it. You must study every detail, master every principle governing it, just as your employer has done; and then, at last, you will be able to save him some work, and become worthy of increased payment. Whether your employer is foreman, chief of department, superintendent, manager, or proprietor, the principle governing your wages is the same—you must learn his work, or you can never advance.

Books contain the kind of knowledge you need, only a little out of date. Trade papers contain much more recent information, but without systematic arrangement. The best and latest statements of experience are found in the technical courses of a good correspondence school.

Your eyes and ears will also furnish invaluable information about methods and processes in the places where you work.

Do not be afraid to ask questions. The foreman will show you many things connected with the work, if you ask him to. So will the superintendent. It is part of their business to increase your efficiency; one of their heaviest burdens of responsibility is to keep raising the standard of the works and to increase the efficiency of the most intelligent men, in order to have some on whom they can call for special work or a promotion. Make your superior officers realize that you are intelligent and that you propose to qualify yourself for higher work.

Hundreds of the rich and influential men of this country were once doing exactly what you are doing—at the bench, working as a carpenter or a journeyman plumber, or in some other trade. Find out what you can about the career of some such man that you know of. How did he come to rise above his fellows? Favoritism has helped a few successful men; but the vast majority improved their spare moments to learn things they could not learn from merely handling a hammer and a chisel. Their hammer blows were not delivered sleepily or lazily. Every moment was energetic and alert from the expectation of better things, and the determination to do everything in the best possible way.

You will be able to handle even chisel and hammer better, if you observe and study how other successful men handle theirs.

Behind the success of every man that has not risen through fraud, lies a history of details mastered, of hard problems solved, such as you are now meeting, of methods improved through study, and of careful preparation for each higher position.

If you proudly claim to be a "practical man," and do not prove your claim by mastering the experience of other men more practical and successful than yourself, you may be certain that you can rise in life only slowly and with difficulty; that probably you will not rise much above what you are now; and that sometime you will be likely to give up your place to some one who knows more than his own tools have taught him.

It will always be a source of surprise to many people why the man who directs is better paid than the man who executes. They see a railroad manager traveling around the country in a magnificent private car, dictating letters to his secretary, issuing orders broadcast, and

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doing very little manual work. They notice that a chief engineer spends much of his time at a desk overlooking the engine room, and seldom touches the machinery under his charge. Yet both manager and chief receive salaries largely in excess of those of the subordinates who bend over the desk or are busy with the engines all day long.

Such men know all the "ins and outs" of the work of which they are the head, and could if necessary, fill any position from the lowest to highest. The manager of a railroad, who, it may be, began life as a brakeman, knows how to couple cars, take up tickets, audit accounts, and so on up to directing the affairs of the entire system. The chief engineer knows how to fire boilers, repair engines, and every other detail of the work. Each one began lower down than where you are now, learned the practice and theory of every step, and now stands as an example of the fact that it pays to know how.

But none of them could have earned their present salaries, if they had been "practical men" furnished only with their own personal experience.

You should never stop at the rudiments of your trade or profession. Do not be content with a few mechanical tricks, but master all the details, know how to do everything from bottom to top, and presently you may let other less enterprising people do the hard work, while you reap the reward of your knowledge.

THE HALL OF FAME

By the munificence of Miss Helen Gould, there has been erected on the grounds of New York University, in New York City, a structure to be known as "The Hall of Fame." In its long colonnade are vacant spaces for the names of one hundred Americans, the most famous of the country. Twenty-nine names have just been chosen.

THE HALL OF FAME

It is profitable to observe what influence education had on the careers of these twenty-nine to make them worthy of so distinguished an honor. Of the entire number, eighteen received a college education, while eleven were self-educated.

The ten statesmen and jurists are equally divided between college and self-educated men. Two military heroes received the equivalent of a college education, while one did not. The two artists are equally divided. But one, out of three authors, was self-made. The same is true of the two inventors. All three of the great theologians were college men; as was the single great educator. The only botanist chosen was a college man. The single naturalist was not. The two greatest American philanthropists tasted in youth but the rudiments of education.

It is a remarkable showing, containing worlds of encouragement for solitary seekers after truth, that so large a proportion of America's greatest men as eleven out of twenty-nine should have been almost wholly without the advantages of a good education.

The immortal Washington, who stands easily at the head of the list, received no school training after he reached the age of sixteen. The limit reached seems to have been the subjects of reading, writing, arithmetic, and a little geometry and surveying. He was, however, an extremely conscientious and painstaking student in everything that he took up.

Abraham Lincoln's advantages may be known

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from what he says of the schools in which he received his little instruction, "No qualification was ever required of a teacher beyond readin', writin', and cipherin' to the rule of three. There was absolutely nothing to excite ambition for education." In spite of such an obstacle, Lincoln became a well educated man, because he made the best use of the limited opportunities afforded him and learned all that the half-educated backwoods teachers could impart. He read all the books he could find, over and over again. Like Washington, he practiced the famous rule, "To remember, write," by putting in writing, from childhood up, his recollections of what he had read and his impressions of what he saw about him.

Benjamin Franklin, whose enduring fame is known worldwide both in circles of statesmanship and science, was another insatiable reader, and turned all of his few shillings into books. All the school education he had was little more than a year before he was ten years old.

The greatest of American jurists, Chief-Justice Marshall, never received college training.

The schooling of Washington Irving, one of our most famous authors, was finished at sixteen. It was not at all thorough, for he had nothing beyond the English branches but the merest smattering of Latin. But, like all other self-educated men, he read, intelligently and voraciously, many good books.

Most of our military heroes were educated at one of the national academies, but our greatest admiral, David G. Farragut, was in the navy at ten and in command of a prize crew a little later, though having had only a little schooling, in Louisiana and at Chester, Pennsylvania.

Henry Clay, the great compromiser, who by his tactful adjustment of vital differences, many times saved the Union from civil strife, received some elementary instruction in a log schoolhouse, but at fourteen was clerking in a store, his school days ended.

George Peabody and Peter Cooper, the two greatest philanthropists, had few educational advantages, the former learning to read and write before he became a clerk at eleven, and the latter having been limited to half days during a single year.

It is plain that the greatest and best-known names in The Hall of Fame are not among those who had a college education, or its equivalent, though many bright ones are found among the eighteen college graduates honored by a place among the hundred—Webster, Grant, Jefferson, Emerson, Longfellow, Jonathan Edwards and Channing the theologians, Morse, Hawthorne, Lee, Horace Mann the educator, Beecher, Eli Whitney, James Kent and Joseph Story, jurists, John Adams, Audubon the naturalist, Stuart and Hunt, artists, and Asa Gray, botanist.

There are still seventy-one vacant tablets in The Hall of Fame. Who, of this generation, will cause their names there to stand in enduring bronze? College education, though a great help, is by no means essential to the attainment of this mark of worth. Many of those niches of honor will be occupied by the names of men, now living, who have had no advantages whatever—men who have chosen one aim in life, and unfaltering, determined, and patient, are moving steadily along the difficult path, to win, to the best of their ability, the highest crowns of success within their sight.

THE NEW HIGHWAY TO SUCCESS

Those who desire to succeed in life should put themselves in the line of least resistance to success.

Times change and with them change the broad avenues to success. The methods of a past generation are not likely to be the best for today.

As far back as the memory of living men goes, it has been taught that "Competition is the life of trade." Believing in this maxim, thousands of men, young and old, are still casting about for ways to enter the now narrow and devious pathway of competition, not realizing that the day of competition is beginning to pass away.

It is nothing remarkable that men brought up to believe that the sole avenue to success lies through competition, should imagine that because the way of competition is becoming more difficult, all ways of advancement are

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blocked. It is unfortunate, however, that men who hold such opinions and are sure to be widely quoted in the press, should give utterance to opinions calculated to discourage thousands of seekers for success. For example, in a recent widely-quoted speech, Mr. Richard Croker, of New York, said: "If I were to use a common, every-day expression to convey my idea of the condition of the man who seeks a future, I should say that he is 'up against it.' There is no ladder on which he can climb."

Similar sentiments are expressed by other men, who evidently have not read the signs of the times.

Cries of this kind, however, have been heard for ages. In every century, men, blind to changes in conditions, have proclaimed sadly that the last avenue to success was closed. Such words have discouraged thousands through the prominence of the speakers, not because they were true.

On the other hand, far-seeing and practical men, have shown the falsity of the claims of this worst class of calamity criers; and there are not wanting today, fortunately, many to announce new avenues to advancement.

It is in the employ of large corporations that the best opportunities exist today. It is not clerkships only, that these concerns offer to the ambitious. Any man who, in addition to a substantial character, possesses enterprise, and education enough to successfully hold a subordinate position, can advance in their employ to the very limit of his capacity, and will do as well or better than if he were in business for himself. Above the clerks' and laborers' places in large concerns are foremanships, chiefships and managerships of departments, superintendencies, and the great positions of management.

With the gradual disappearance of the small firm is going much of the gross favoritism that has dampened the ardor of many an aspirant for advancement. While influence may secure a position in the employ of a great corporation, the interests at stake are so vast that the employe—whether manager or clerk—quickly gravitates up or down until he reaches the place commensurate with his worth.

Not every one desires to become a Rockafeller, Carnegie, Gould, or Field. To reach the dizzy heights of financial success on which they stand, one must be a specialist in money-making, to the exclusion of much else. "Celebrity," says Emile Sonvestre, "sells dearly what we think she gives." "A great fortune," said Seneca, the Roman philosopher, centuries ago, "is a great servitude." Great fame or enormous wealth are not the most desirable things in the world.

The average man is not able, nor does not care to bear the crushing burden of responsibility imposed by such success.

Below the lofty pinnacles of success are a host of good positions guaranteeing excellent incomes, with no greater load of care than a man can carry and at the same time make much of himself in ways that produce more happiness than all the money and publicity of the highest places.

These lower places are open to all comers who will prove their worth. No man is too old, no boy too young, to be out of the race for the lesser and really more desirable prizes. We know of numbers of cases where men of fifty or more, and boys under twenty have advanced to very desirable positions, as a result of self-improvement recently entered upon. Every man who feels that it is in him to successfully hold a higher position than he now occupies, has today a better chance of gratifying his ambition than he ever could have had before. Not only is the industrial world quicker than ever before to recognize capacity for advancement and accord it its due, but there are now many means of self-improvement that did not even exist ten years ago.

Let every man who wishes to advance, first see to his character, that he is forceful, earnest, and thoroughly reliable. If deficient in any trait, he should take particular pains to cultivate it and thus lessen his chances of failure.

Let him manifest enterprise in his work, and show himself a man of more ability than is required in his present position.

Let him, finally, study the theory and practice of the positions above him, so as to be qualified for a responsible place.

The unsatisfied demand of the business and industrial world is for men who have prepared themselves for better things. Even though the competitive system of business should disappear completely, opportunities will never be wanting to the man who is ready.

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HELP Along the Coupon Canvass, Page 14.

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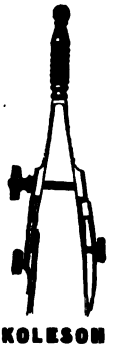

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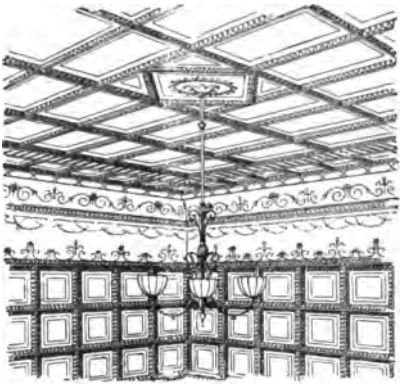

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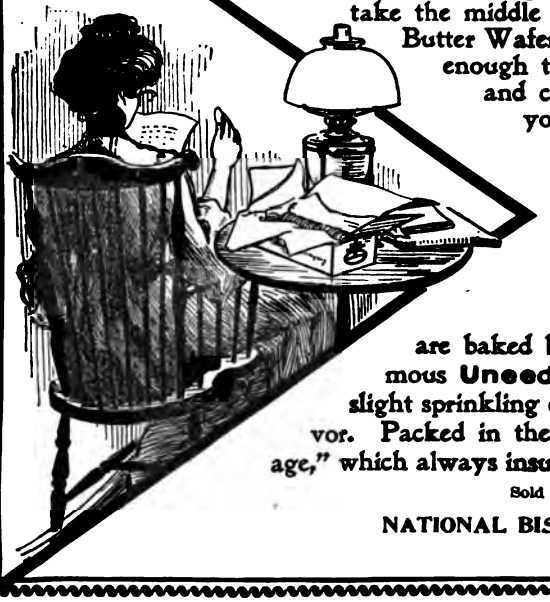

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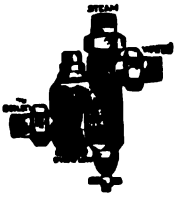

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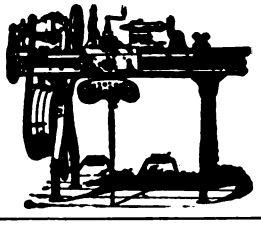

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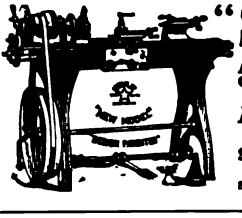

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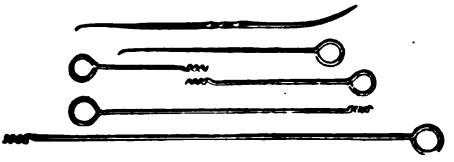

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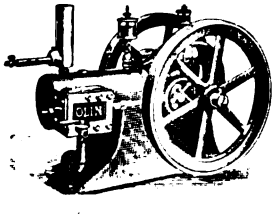

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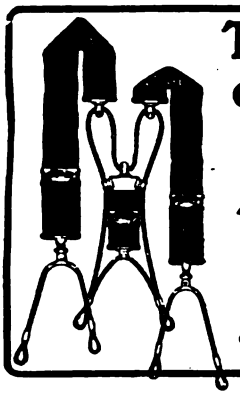

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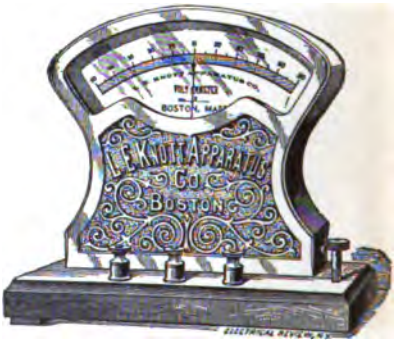

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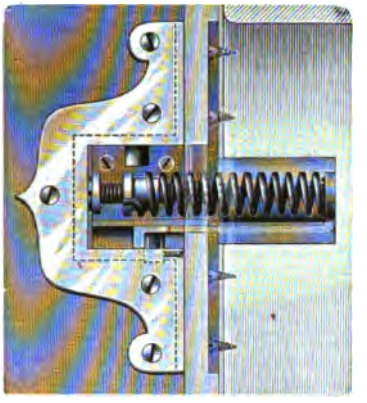

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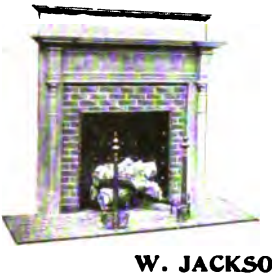

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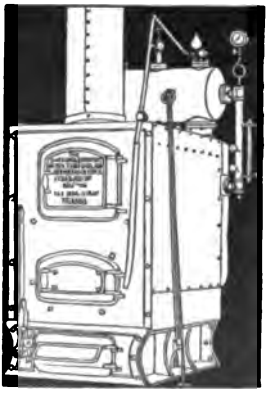

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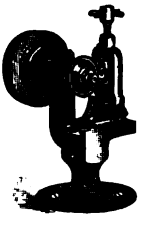

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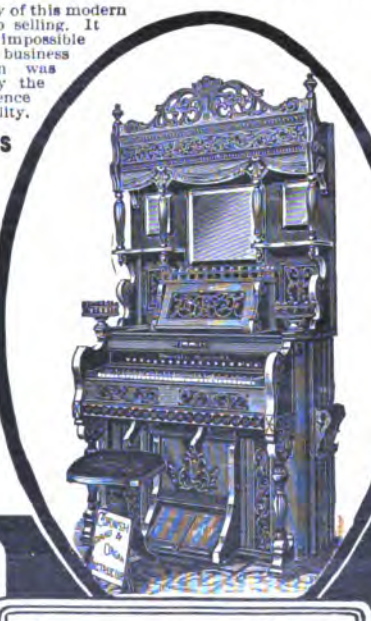

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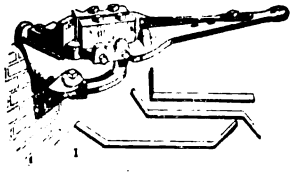

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